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FIRE AND GAS DETECTION IN THE LHC EXPERIMENTS
THE SNIFFER PROJECT

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Abstract

The LHC experiments, due to their complexity and size, present many safety challenges. Cryogenic gases are used in large quantities as well as certain flammable mixtures. The electrical power involved calls for analysis of the fire risks. Access is restricted to the minimum and environmental conditions are extremely harsh, due to strong magnetic fields and ionising radiation. This paper will describe the Combined Fire/Gas/Oxygen deficiency Detection systems proposed for inside the ATLAS and CMS Experiments and possibly for the two others, if they deem it necessary. The requirements of the experiments and the development and implementation of such a system will be discussed. In parallel, commercial procedures to implement these systems by industry shall be described, taking into consideration that a previous development has already been undertaken by CERN for the LEP experiments. The stage is set for inter-divisional collaboration in a project of utmost importance for the safety of people and protection of the investment.

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1 INTRODUCTION

For the LHC Experiments, a great number of alarm systems shall be installed in different locations: on the surface, in the underground technical and experimental caverns and inside the Experimental Apparatus. In this paper, only the latter shall be discussed.

Both the ATLAS and the CMS Experiment have requested the installation of alarm systems capable of detecting different hazards developing inside the volume of the Experimental Apparatus. These consist of Fire in an incipient stage, the presence of Flammable Gas or Low Oxygen levels dangerous for human life.

The ST Division has been charged with developing and supplying such systems for these experiments, and would like to be ready to receive similar requests coming from the remaining two experiments, ALICE and LHCb.

2 PROJECT DESCRIPTION

Because of the lack of space and hostile environment, such a system can almost only consist of a network of air sampling perforated tubes accessing the inside of the Experimental Apparatus. These tubes would bring a sample of the air present inside the Experiment Volumes to detection equipment placed outside.

Due to the nature of this project, the name SNIFFER (**S**ystem to **N**ail **I**mportant **F**ire and **F**lammable gas **E**xperimental **R**isks) is proposed.

This project shall be executed by CERN's industrial partners specialised in this field, with the requirements and supervision by CERN.

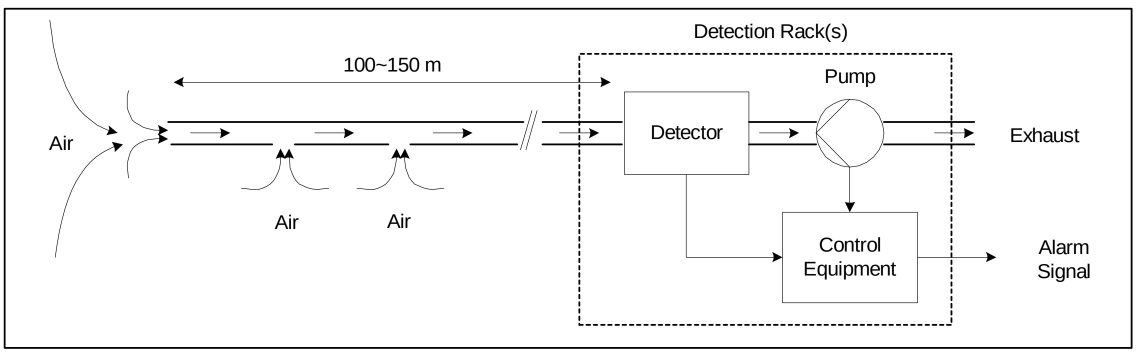

Figure 1 Principle of Air Sampling Detection

The technique is known and widely applied in industry and consists of a tube connected to a pump with a detection device in the middle. (Figure 1). However CERN is requiring a simultaneous detection of three different phenomenon: Smoke, Flammable Gas and Oxygen deficiency. This is a complex combination, taking into account the very different aeraulic characteristics of smoke and gas detection. The former has very sensitive detectors capable of detecting the most minute particle of smoke and works generally with high air flows and large tube diameters (~20mm). The latter has less sensitive detectors and works with less air flow and smaller tube diameters (~6~8mm)

The large dimension of the experiments presents a further difficulty. Being located more than 100 m underground and of cylindrical form, ATLAS spans approximately 40m in length and 25m in height (see Figure 2). This will make for very long lengths of the sampling tubes and consequently high pressure drops, implying high power pumps. High power pumps in turn take up space, and space is a valuable asset in the underground facilities and the size of the equipment must to be reduced to a minimum.

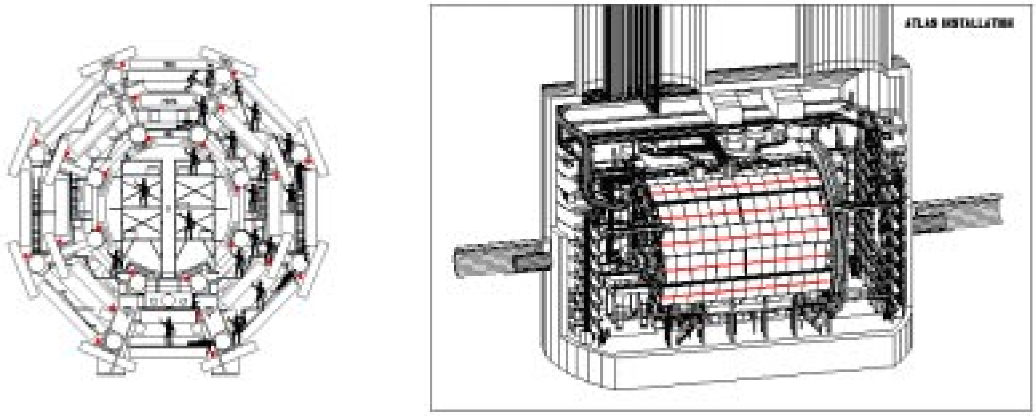

Figure 2 Basic illustration of the foreseen location of the sampling tubes (red lines) in ATLAS

3 THE LEP EXPERIENCE

For the detection of fire and flammable gas inside the LEP (Large Electron-Positron) Experiments the EST/LEA group built, more than 10 years ago, the SDN (**S**ampling **D**etection and **N**eutralization) system. This system applied the air sampling principle described above to detect hazards inside the experiment. It had the additional capability of injecting an extinguishing gas to neutralize any incipient fire.

Twenty of these systems were installed in the LEP Experiments, and provide an invaluable return of experience to aid in the design of the new systems.

It was developed and produced at CERN and is described in detail in [1].

4 REQUIREMENTS AND TECHNICAL CONSTRAINTS

4.1 Basic Requirements

The basic requirements from the experiment's point of view is of extreme simplicity:

- The SNIFFER must be able to detect inside the Experiment:
    - Smoke presence (indication of fire)
    - Flammable Gas due to a leak
    - Low Oxygen levels due to a leak of inert Gas.
- The response time must be within 100 seconds

4.2 Quantities

Because of the dimension of the Experiments, they have been divided into volumes inside which the detection system must work, but they are not isolated from the each other. The volumes are only representations of areas inside the detector.

For example the ATLAS detector has been divided into slices, each being a volume, and the ATLAS Group has estimated the need for approximately 250 tubes. CMS is estimated to require approximately 200, and the other two Experiments 50 each.

4.3 Constraints

The main constraints on the SNIFFER are Distances and Response Time, Space and Location, Radiation, Magnetic field and Access. All these constraints are interconnected.

The response time depends heavily on the length of the sampling tube. The response time is the sum of the air transport time and the analysis time. The longer the tube for a given air speed, the longer the transport time. So length should be minimized and is expected to be on average of 100m.

As mentioned before, space is a valuable asset underground. The choice has to be made between installing the analysis equipment in the Experimental Cavern or in the Service Cavern.

If installed in the Experimental Cavern, distances and response time will be minimized but the environment is hostile with Radiation and Magnetic Fields perturbing the functioning of the system and degrading performances.

If installed in the Service Cavern distances will be much longer, and consequently the pressure drops shall increase, calling for larger pumps that take up more space. The environment is no longer hostile, but the air passing inside the detection system has to be re-injected into the experimental cavern because of possible radioactive dust. The equipment itself may become slightly active and may constitute a radiological problem inside the Service Cavern.

Furthermore the Experimental Cavern is under strict Access Control, creating difficulties for maintenance and repair operations. The presence of the whole system in the Service Cavern would ease the maintenance operations.

Due to the large number of detectors needed a solution must be found so as to take up the minimum space. The maximum number of tubes must be analyzed using the minimum number of racks. This may call for solutions such as multiplexing of tubes or development of very small sensors.

4.4 Reliability

The SNIFFER must also guarantee reliability and performance, and must undergo a detailed functional analysis, and be able to demonstrate that it complies to the SIL2 (Safety Integrity Level 2) as specified in the IEC 61508 [2].

4.5 Integration into CSAM

Of course the SNIFFER must also integrate with CSAM (CERN Safety Alarm Monitoring) system. It must be able to transmit its information (e.g. analogue values, alarms, faults, state changes, etc…) via a communication protocol compatible with the CERN standards, and be able to activate safety actions and emergency shutdown operations. For more on the CSAM system see [3]

5 PROJECT ORGANISATION

The project should have a structure and its main actors should be organized in such a way as to define the requirements, provide resources, monitor and control progress and performance.

For this purpose, we propose the classic project-management structure (see Figure 3):

- Product Owner – *Maître d’Ouvrage*
- Product Manager – *Maître d’Ouvrage Délégué*
- Project Owner – *Maître d’Oeuvre*
- Project Leader – *Maître d’Oeuvre Délégué*

Each Experiment shall have its own Product Owner and Product Manager. In fact, there shall be four different projects, with four different Product Owners and Product Managers, but with the same Project Owner and Project Leader.

For each Experiment the Product Owner should be the corresponding Experiment coordinator, and the Product Manager should be the corresponding GLIMOS (Group Leader In Matters Of Safety).

The Project Owner should then be the hierarchy of the ST Division charged with accomplishing this project, who delegate the execution to the Project Leader, the ST/AA/AS section leader. He shall coordinate the internal CERN collaborators, as well as insure a correct follow-up of the project and its implementation by the industry.

All Experiments will be slightly different in its constraints and requirements, so it is logical that each case is treated as a separate project in spite of the common need.

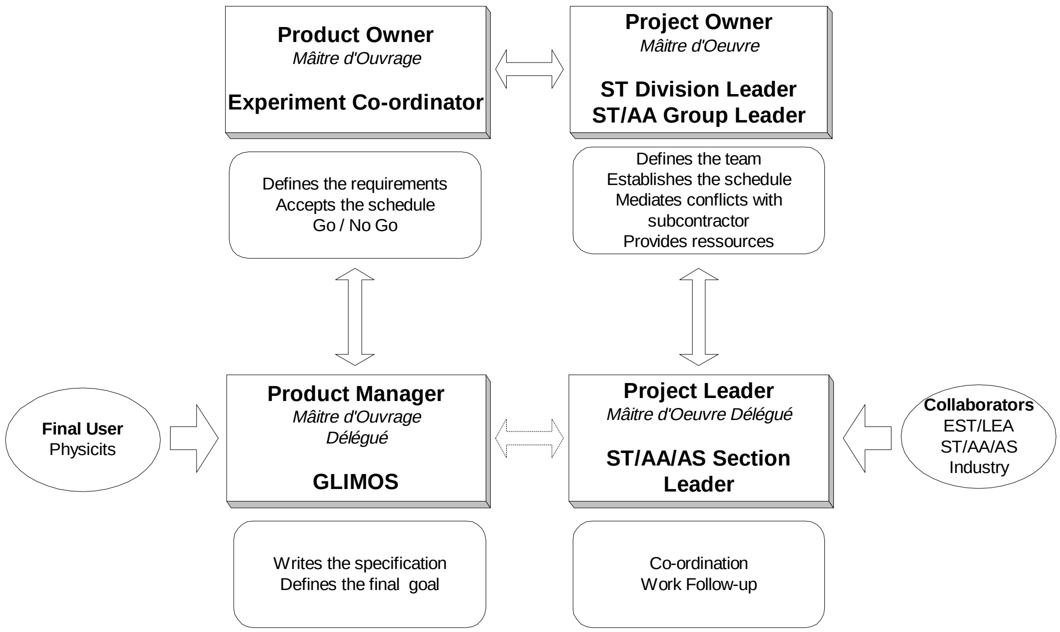

Figure 3 Proposed Project Organization

6 PROJECT MILESTONES

This project shall be developed by CERN's industrial suppliers and should respect internal purchasing procedures. The standard Market Survey followed by Technical Specification must be respected. In parallel however, some development will be sponsored by CERN, due to the novelty of this project.

To make sure that the performances requested by CERN are achievable, prototypes shall be developed to validate the detection principles and assure that the defined detection levels are acceptable.

The objective of this prototyping phase is to learn by experimenting, so that an adequate system can be designed. A functional analysis must be performed on the detection system, to guarantee that it offers functionality and reliability. Testing protocols must be defined for the final system.

A final Technical Specification shall then be written in order to select the supplier of the systems to be installed

During the Experiment assembly, the air sampling tubes must be installed in collaboration with the experiments and inserted into their assembly schedules. A very close co-ordination shall be necessary during this stage.

The main milestones can be enumerated as follows with their indicative dates

- Market Survey (10/2000)
- Prototyping started (02/2001)
- Definition of first constraints (06/2001)
- Validation of Prototype (09/2001)
- Final Specification and Invitation to Tender (01/2002)
- Implementation and Acceptance Tests (2003-2004)
- Maintenance (2005)

Between the start of the prototyping and its Validation the milestone referring to First Constraints is of crucial importance. Due to the CMS assembly schedule, the first tubes have to be assembled with the detector in June 2001. At this date, the dimensions of the tubes must be determined, so that no further intervention is needed to install tubes in an already assembled experiment.

7 CONCLUSION

The final goal of this project is to ensure the safety of the personnel entering the experiment, and prevent any major damage to the invaluable equipment in the LHC Experiments.

This challenging project, within a complex organization is also technically challenging, pushing our industrial partners to provide ingenious solutions and CERN to new approaches to engineering projects. No longer are they performed in-house, but instead rely on the competence of industry. In this sense a strong collaboration is required between CERN and its industrial suppliers, who have up to now provided many useful ideas.

8 ACKNOWLEDGMENTS

A special thanks to J. Nebout, who has been the driver of this project from the start (under a different project name). Lots of ideas come from him, who has designed the LEP SDN stations and is preparing to contribute significantly to the development of the SNIFFER.

REFERENCES

[1] Guy Roux, Michel Jenin, Joseph Nebout, «*Genève: Le CERN Expérimente en Sécurité*», Face au Risque Nº 268 Décembre 1990

[2] International Standard IEC 61508 – Functional safety of electrical/electronic/programmable electronic safety related systems

[3] S. Grau, P. Ninin, R. Nunes, L. Scibile, C. Soler, 3rd ST Chamonix Workshop Proceedings, CERN-ST-2000-016, « *CERN Safety Alarm Monitoring Project* »