SAFETY ORGANIZATION AND SAFETY STATUS OF THE LHC EXPERIMENTS

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Abstract

The LHC experiments have reached very high levels in matters of safety to face all possible risks associated to the LHC Run Period.

Following appropriate risks assessments, the required level 3 alarm safety systems have been installed and are operational. The radioprotection strategy has been set up, the adequate general and specific safety trainings have been developed.

The Experiments safety organization and structures have been reinforced with: SLIMOS in the control rooms, radioprotection experts and assistants, patrollers, safety officers.

The Experiments SLIMOS desks in the control rooms are playing a key role in this safety organization: controlling all safety and infrastructure data and operating a strict control and coordination of all experimental areas access, activities and emergency situations.

Finally, all safety measures have been implemented to protect the caverns in case of re-occurrence of Helium accidental release in the Tunnel areas.

INTRODUCTION

The LHC experiments have in the past years implemented very high safety standards in the experimental areas to be ready for the LHC operation. The Experiments are ready to safely operate in Run period and during the LHC Machine Shutdowns:

After appropriate risks assessments, the required Alarm level 3 safety systems have been designed and installed: fire, oxygen deficiency and gases detection, specific Sniffer system, etc.. These systems have been commissioned and are currently under maintenance control.

In order to cope with the complexity of the experiments and the experimental areas, the Experimental safety structures have been reinforced. In this organization, a key role has emerged: the SLIMOS, Shift Leader in Matter of Safety to whom the GLIMOS delegates his functions in the experiments control rooms. In addition, a strict control, analysis and planning of all activities is performed by the experiments.

In addition, a close collaboration has been set up with the CERN Fire Brigade.

The Experiments radioprotection strategy has been set up in collaboration with the CERN radioprotection group. The required associated radioprotection equipments have been installed and the safety procedures are operational.

Finally, following the accidental Helium release of 19.11.2008, the experimental caverns have been pressure protected and sealed. These protections are mostly also fire resistant.

As side benefits, the caverns and tunnels overpressures have been highly improved. And most of the experiments reach today the 20 Pa overpressure required for radioprotection and fire safety.

EXPERIMENTAL AND SERVICE CAVERNS PROTECTION AGAINST AN ACCIDENTAL HELIUM RELEASE

During the long shutdown 2008-2009, an extensive protection campaign has been run in the 4 experimental underground areas to protect the service and experimental caverns in case of the reoccurrence of an accidental Helium release in the tunnel areas following the Safety task force recommendations.

It was especially requested to seal the LHC tunnel towards other underground areas to protect them from oxygen deficiency and from overpressure.

The maximum possible overpressures were assessed by the Safety Commission for each relevant interface between the tunnel and the experimental or service areas associated to minimum gas temperature of 200 K.

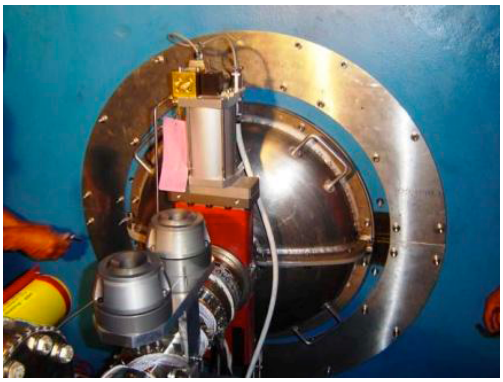
All structures interfacing between the tunnel and the service or experimental caverns have been analyzed versus these constraints and redesigned when required. A very tight sealing have been performed in order to guaranty air tightness between the tunnel and the other underground areas volume. When required and if possible, the modified structures have been rebuilt to ensure also fire protection.

ALICE pressure resistant partition/door between US25 and UL26.

ATLAS Survey hole between tunnel and UX15 cavern survey galleries

The TAS regions at the interface between the experimental caverns and the tunnel areas in CMS and ATLAS have been redesigned taking into account the ALARA, As Low As Reasonably Achievable, radioprotection strategy in addition to the other constraints. ATLAS and CMS have developed two different design solutions adapted to their specific configurations that are shown in the figure below.

CMS TAS protection design.



ATLAS TAS protection design.

In addition, the ventilation doors have been instrumented and connected to the LACS system, LHC Access Control system, in order to monitor their positions. In future and if required, the ventilation doors could be connected to the LASS, LHC Access Safety system, and inserted in the chain of interlocks. As a consequence of this protection campaign and thanks to the collaboration with EN-CV group, the overpressures between the experimental caverns and the tunnel have been highly improved. This is a side benefit for radioprotection and fire protection.

ATLAS and CMS reach in Run mode the required overpressures:

- Between service caverns and experimental caverns (> 20 Pa)
- Between experimental caverns and tunnel areas (> 30 Pa)

Due to the ventilation system configuration, LHCb overpressures still need to be improved. This is addressed in Mauro Nonis proceedings.

ALARM LEVEL 3 SYSTEMS STATUS

The safety systems have been audited in the four experimental areas in 2008. An audit update campaign has been performed in 2009.

The level 3 safety systems are operational and under maintenance control. It has to be noticed a special care will be taken in the coming years to coordinate the system maintenances that none of them exceed their annual limit in the specific context of two years run.

The coverage of the alarm level 3 safety systems has been reinforced during the long 2009 shutdown. As an example, additional oxygen deficiency detectors have been installed in CMS survey galleries for an early detection in case of a reoccurrence of He release in the tunnel areas.

Following the 19.11.08 accidental Helium release, the evacuation matrixes are currently under revision process. The main issue is the evacuation of the experimental caverns when there is a confirmed oxygen deficiency alarm in the tunnel areas. Depending on their specific topology, the four experiments have different strategies: automatic evacuation of the experimental caverns or evacuation triggered by the SLIMOS.

In all cases, the issue of the missing second evacuation path, and the risk to evacuate via dangerous areas are raised.

A global analysis of the whole LHC areas evacuation is on going in collaboration with the Machine safety responsible.

EXPERIMENTS SAFETY STRUCTURE AND ORGANIZATION

In order to cope with the complexity and the specificity of the detectors and of the experimental areas, a reinforced safety organization have been set up by the GLIMOS in the past years. This is one of the main parameter to guaranty very high safety standards in experimental areas and a safe operation of our detectors.

The Experiments safety structures are leaded by the GLIMOS who is responsible and represents the experiments safety organization in front of the various CERN departments, safety partners and committees and in front of the experiments collaboration institutes.

Several groups of specialized safety experts belongs to the Safety Structure and report to the GLIMOS.

In first place, the GLIMOS is assisted by a team of engineers and physicists for all matters directly related to safety and database projects: alarm level 3 safety systems, detector safety systems, safety related databases development and maintenance, etc...

Safety Officers, engineers or physicists, have been nominated in the various safety fields: cryogenics, electricity, flammable gases, territorial, lasers, radiation. They act as safety officers specifically for the experimental areas.

A radioprotection organization of engineers, physicists and technicians has been set up around the GLIMOS and the radiation safety officer, RSO. This structure is responsible to organize, implement and perform the radioprotection tasks for the experiments.. Radioprotection Experts, so called RPE, who are engineers or physicists and Radioprotection Assistant, so called RPA, who are technicians have been certified by external national radioprotection authorities and are regularly trained by the CERN RP group and the experiment RSO. It shall be reminded that the radioprotection at CERN is under the authority of the CERN radioprotection group.

All the activities and accesses happening in the experimental areas are controlled by the Work Package Analysis organization, during the LHC Run and Shutdown periods. The responsible of any type of activity (infrastructure or detectors) shall declare the activity via work declaration forms. He provides the appropriate safety and working information to the work package analysis team.

A description of the work, the criticality of access, a proposed activity schedule with the required warning time, the required tooling is provided with the estimated time of intervention and the detailed region of access. All safety aspects and risks linked to the activity are provided via the so called PPSPS documents and analyzed during the Work Package Analysis (WPA) meeting by the GLIMOS or Experimental Area manager, all required safety experts and Technical Coordination responsible in presence of the activity responsible. The radioprotection aspects and especially the optimization of the individual and collective dose rates are analyzed by the ALARA engineers in collaboration with the CERN RP group; this is an input for the WPA meeting. The list of intervening persons associated the required safety trainings, medical certificates, and in near future associated dose budgets are also analyzed during the meeting.

Finally, the activity is approved by the Technical coordination. In Run period, the criticality of the work is assessed by the Run Coordinator who proposes a schedule to the agreement of the LHC Program Coordinator.

Depending on the experiment, this organization is leaded by the GLIMOS or by the EAM, Experimental Area Management.

A key role for the safety of the Experiments is the SLIMOS: Shift Leader in matter of Safety. The Experiments safety, infrastructure and access data converge to a central location: the SLIMOS desk.

All these data are analyzed and treated by the SLIMOS to which the GLIMOS delegates part of his safety duties together with the necessary authority. The SLIMOS are engineers or physicists especially trained for their safety duties. They follow regular information and instructions

campaign on safety systems, safety procedures, access systems, … In ATLAS experiments, weekly SLIMOS meeting are organized in order to collect the feedback from the shifters and to provide regular safety trainings.

Generally, the SLIMOS coordinates actions resolution after a level 2 or level 3 alarms occurring in the experimental areas. He interacts the Fire Brigade, the CERN Control Center, CCC, and the infrastructure and detectors experts.

During the LHC Run period, the SLIMOS coordinates the cavern opening and closing process, mainly he perform the following tasks:

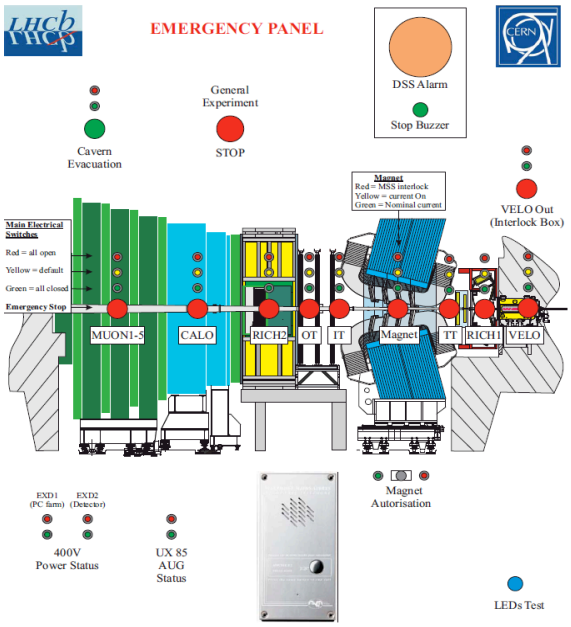
- Check of the caverns safety conditions: presence of alarms, infrastructure status, ventilation system modes (Run mode or Access mode), cavern overpressures (for ATLAS and CMS detectors), …
- Coordination of the radioprotection experts and safety team interventions: radiation veto removal, material activation control, control of the cavern status before closing, …
- Run the access systems opening and closure procedures in collaboration with the CERN Control Center.
- Strict control of the persons and material going in and out during the intervention
- Control the personnel required safety training, medical certificate (for ATLAS magnetic field)
- Provide the required specific safety equipment (CO2 and ODH personnel detectors for ATLAS experimental cavern for example).
- When required coordinate patrol interventions.

The SLIMOS documentation is available in the experiments SLIMOS handbooks web pages. This is a web link to all SLIMOS and infrastructure data and procedures. This documentation is composed of users manuals, systems description, and specific procedures for SLIMOS, patrollers, experimental area users, radioprotection experts and assistants.

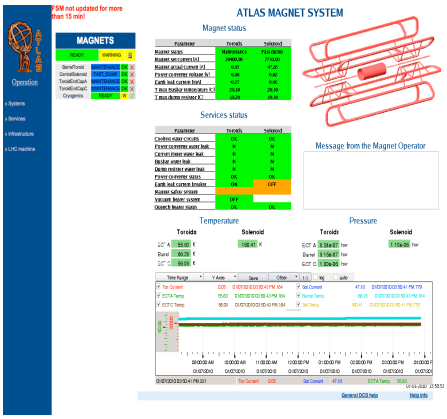
It is specifically related to the following items:

- Alarm systems (CSAM, DSS, Lasers, etc.)
- Safety systems and alarm/action matrixes
- Access control (access procedures, access control and safety systems, web cams, etc.)
- Infrastructure parameters (electrical power, cryogenics, magnets, cooling and ventilation, gases, etc.)
- Fire Brigade documentation and specific intervention procedures
- Radioprotection (radiation monitoring system, specific procedures, etc…)
- Safety equipment status and monitoring
- Public and professional visits procedures and database.

The infrastructure and safety parameters are consultable in real time at SLIMOS desk and through the experiments restricted access web pages. The web pages use the DIP published data.



LHCb Emergency panel web page



ATLAS Magnet Status web page.

It has to be noticed that the organization of safety for the experiments forward detectors shall be clarified.

As far as the safety organization is concerned, CMS has opted for a structure that includes a second outfit with responsibilities complementary of those of the GLIMOS:

The Experimental Area Management (EAM) team. This outfit holds the overall responsibility when it comes to the work package analysis activities. The meetings are called and chaired by the EAM team. Subsequently, the EAM team ensures that the recommendations made during the meeting (detailed planning & coordination, work method, safety aspects) are implemented on site. The EAM team also has clearly defined responsibilities regarding access management to the experimental area. Access requests from users are primarily treated by the GLIMOS, while the Experimental Area Manager treats the ones from contractors and CERN staff. As a general rule, the CMS GLIMOS has as a prime responsibility the safety of the CMS detector and collaborators whereas the EAM focuses on the safety of the experimental area (i.e. infrastructure, interface with LHC machine…) and the CERN personnel and contractors. When it comes to managing general safety projects, the EAM team also plays a clearly defined role in the preparation and execution of the activities alongside the CMS GLIMOS. The CMS EAM team belongs to the EN department, has no hierarchical link with CMS GLIMOS but works in very close collaboration with him and his team.

THE COLLABORATION BETWEEN THE CERN FIRE BRIGADE AND THE EXPERIMENTS

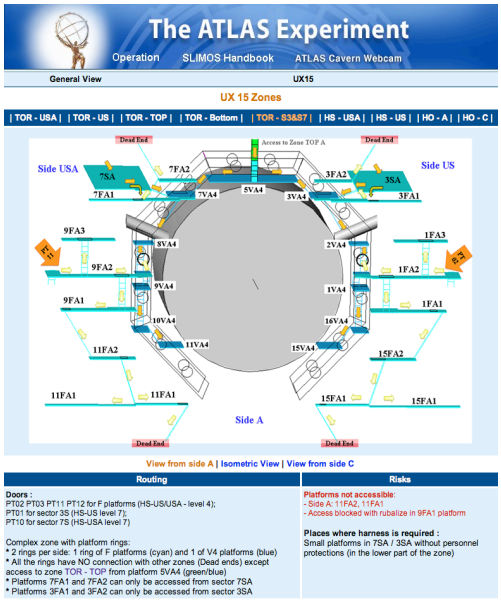
Due to the complexity of the experiments, the Fire Brigade requires specific information and assistance for their interventions inside the experimental areas, especially inside the ATLAS experiment. A collaboration program has been developed in the past years between the LHC experiments and the Fire Brigade. This program is composed of specific collaborative procedures, training campaigns and specific information about the experimental areas.

Fire Brigade Intervention inside ATLAS detector areas.

The general emergency procedures are currently under finalization process. These procedures define the main intervention steps in case of an emergency inside the experimental areas. They precise the roles and responsibilities of both parties: the SLIMOS/GLIMOS and the Fire Brigade intervention teams. They also remind the collaborative interactions between the Fire Brigade and the Experiment safety responsible.

An experimental site familiarization is organized by CMS and LHCb. ALICE and ATLAS experiments have developed a formal experiment training which is delivered regularly to the Fire Brigade team and in any case to each new comer. These trainings explain the SLIMOS and GLIMOS role, remind the basic intervention procedures, detail the experiments topology and specific risks. In ATLAS case, when the experimental cavern access is possible, the training includes a familiarization of the ATLAS detector internal areas, so called Toroid area.

Indeed, the ATLAS Toroid area is an example of complexity: it is composed of few hundred meters of platforms punctuated by ladders, small diameter holes, traps, etc. Some platforms require use of harnesses. The main ATLAS risks are concentrated in this area: high magnetic field, Beryllium pipe, liquid argon, radioactivity, working at height, CO2 gas concentrations, etc.

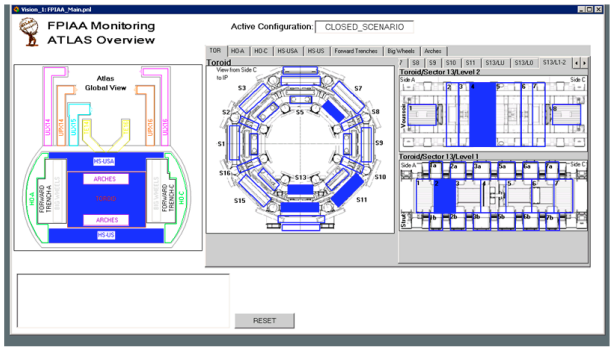


ATLAS Toroid Area topology and main risks web pages.

A naming convention has been developed in agreement with the Fire Brigade to identify the internal platforms. Plates indicating the location name has been installed on all ATLAS detector platforms to assist the FB intervening teams and more generally the ATLAS users.

It has to be noticed that the ATLAS internal topology and the safety risks changes depending on the detector access scenarios. The main access configurations are closed configuration: the detector is fully closed, ready for beam and standard access configuration: the detector is opened, the heart of the detector is reachable, additional scaffoldings are installed.

The ATLAS detector opening configuration, main risks list and location, the topology details and naming convention are available for the Fire Brigade intervention team at SLIMOS desk. They are also visible through the ATLAS web pages.



Finding People inside ATLAS areas

During the emergency, the SLIMOS will indicate to the Fire Brigade, the preferable way to access the region of intervention, the access difficulties (holes, harness, ladders.) and what are the risks in the areas.

The progression of the intervening team inside the ATLAS detector is followed by the SLIMOS and the Fire Brigade head of intervention via a very useful safety assisting device: the FPIAA, Finding People Inside ATLAS Areas tracking system.

This system based on passive infrared sensors detects movement of people inside the areas. It is very useful to detect presence of people and to guide the Fire Brigade team from surface during their intervention.

EXPERIMENTS RADIOPROTECTION STRATEGY AND IMPLEMENTATION

The Experiments strategy in matter of radioprotection has been determined and agreed with the CERN Radioprotection group in the past years.

The procedures have been defined for the various radioprotection tasks: experimental caverns material control procedures, material traceability, radiation veto removal in nominal conditions or in case of emergency…These procedures depend on the radioprotection risks and are regularly revised depending on the luminosity increase.

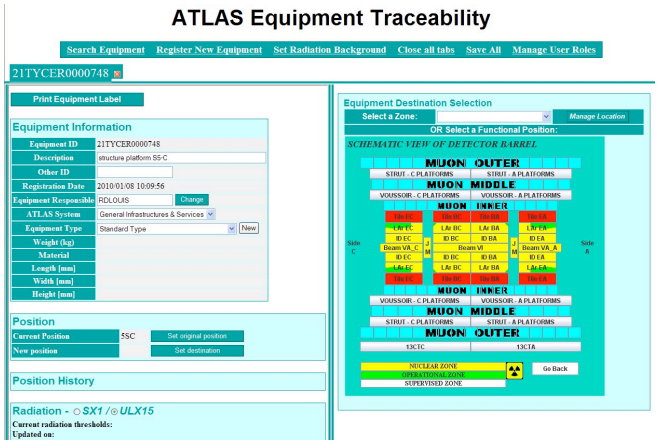
In order to assist the Experiments in their daily radioprotection tasks, experiments radioprotection experts, RPE, and assistants, RPA, have been certified by external national radioprotection authorities and follow a regular training done by the CERN Radioprotection group. The RPE and RPA perform radioprotection tasks in low risks areas (< 15µSv/h). The experiment radiation safety officer, RSO, directly supervises their activities.

ATLAS experiment is the only experiment that remained classified as radiation controlled area after the first LHC beam in September 2008. It is here taken as an example of more than one year of an operational radioprotection strategy.

The RPE and RPA have been acting on shifts since September 2008 in two different modes depending on the LHC mode. In LHC Run period, the shifts are active 24H/7D, during the Shutdown period the shifts are performed only during normal working hours. The RPE and RPA have assisted the CERN RP group and the RSO at the beginning of 2008/2009 Shutdown to perform the experimental radioprotection survey measurements.

During the whole shutdown period, they have performed the material control measurements and traceability records of all material exiting UX15 experimental cavern on the various sub-detectors requests. This is done using the Material Control and Traceability console that is fully operational. This console has been developed by ATLAS, and is taken as common approach by the four experiments ATLAS, CMS LHCb and soon ALICE.

All material exiting the ATLAS experimental cavern are measured labeled and traced in the material database via a GLANCE interface.



ATLAS Database – GLANCE interface.

Radiation gate monitors at UX15 cavern exit

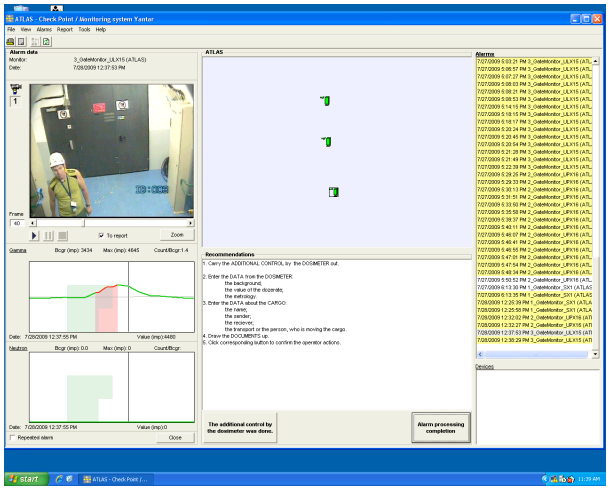
ATLAS RP measurement and traceability console.

The ATLAS radioprotection philosophy has defined that all material taken out of a zone that has been estimated as potentially radioactive shall exit the experimental cavern through the shafts and be delivered directly in the surface Buffer zone.

In order to prevent an accidental or volunteer transfer of radioactive material through the experimental cavern exit doors (PAD, personnel access device or MAD, material access device), radiation gate monitors have been installed at the cavern exits and at surface buffer zone exit to detect any radioactive material going through. The gate monitors are installed before the access PADs.

In case of detection, at gate monitor location, a video surveillance will start to record; siren and flashes will be activated to alert the person exiting.

In the ATLAS control room, an alarm will alert the SLIMOS who will immediately initiate an emergency procedure with the assistance of the RPE on shift, the RSO, the GLIMOS and the RP engineer on shift.



ATLAS Radiation gate monitors alarm screen.

Campaigns of control of radiations calculations and of the radioactive areas will be systematically run during each major long shutdown. The activation calculations have highlighted the zones where the material can potentially result to be radioactive during the ATLAS openings. About 95 samples have been placed inside the detector and experimental area to be analyzed at each

major shutdown by the radioprotection group in order to confirm the calculations and the radioactive zones boundaries.

The ATLAS ALARA, As Low As reasonably Achievable, organization and strategy are currently been set up. ATLAS took the opportunity of the 2008/2009 long shutdown to record the ATLAS detector closure scenario in order to prepare for the ALARA studies. In agreement and collaboration with the intervening teams, all the relevant steps of the various activities were filmed:

- Detector movements operations
- Survey activities
- Beam pipes activities
- Scaffolding and crane activities, etc.

The relevant ALARA data: activity location, time spent, person expertise, etc. have been recorded and are vital for the future ALARA process. These data are currently under treatment with especially the calculation of doses per activity and per type of personnel, the process optimizations, etc…

As a conclusion, in the 2008/2009 shutdown period, the ATLAS collaboration has gained experience and has carefully followed the material handling and radioprotection procedures.

CONCLUSION

In the past years the LHC Experiments have developed very high safety levels for the protection of their personnel and equipment thanks mainly to a strong organization, several safety projects campaigns, and a key role that is emerging the SLIMOS.

The radioprotection strategy has been implemented, is being experimented and will be developed in the coming years especially for the ALARA aspects.

There is nevertheless some remaining pending safety issues to be solved in the coming years; they are addressed in C. Schaeffer proceedings.