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LHC

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ENGINEERING CHANGE REQUEST

LSS1 - AFP small shielding walls

BRIEF DESCRIPTION OF THE PROPOSED CHANGE(S):

ATLAS Forward Proton (AFP) detector suffers from very close proximity to TCL6 collimators in LSS1, which are the hottest in terms of radiation level in the vicinity of ATLAS Interaction Point. In 2023, very tight TCL6 settings were applied, which negatively affected operation by significantly increasing component failure rate, causing also much higher acquired radiation dose for the AFP team replacing these components. Therefore, an urgent shielding solution was needed and promptly implemented during TS1 in 2023, which noticeably reduced operational issues and component failure. Since even tighter TCL6 settings were applied in 2024, an addition and upgrade to these shielding walls was made.

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DOCUMENT SENT FOR INFORMATION TO:

LMC Participants

SUMMARY OF THE ACTIONS TO BE UNDERTAKEN:

Installation and de-installation of small iron bricks made shielding walls for AFP

Note: When approved, an Engineering Change Request becomes an Engineering Change Order.

1. EXISTING SITUATION AND INTRODUCTION

ATLAS Forward Proton (AFP) detector is thoroughly described in the Technical Design Report [1] and subsequent installation ECRs [2,3]. The layout of the sector A6L1 is shown in Figure 1.

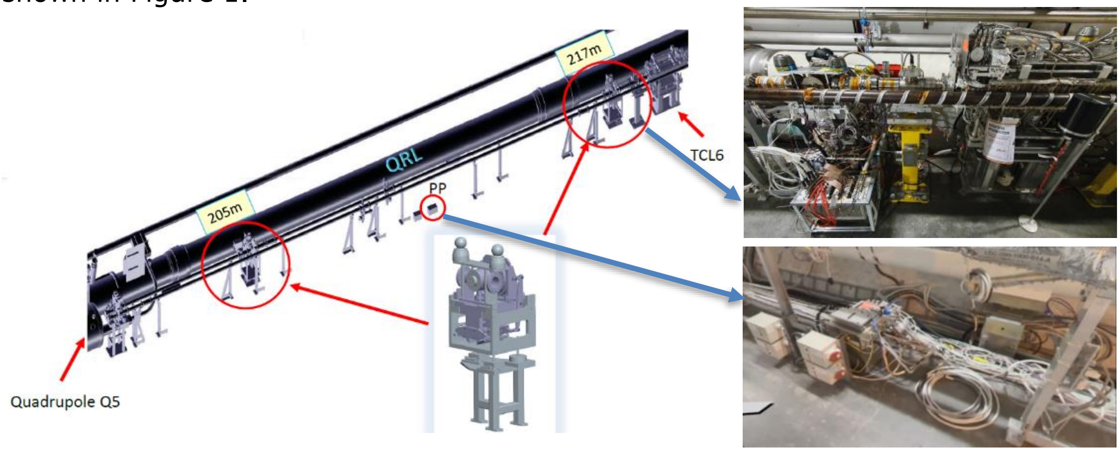

Figure 1 – (left) Layout of sector A6L1. AFP NEAR and FAR (upper right photo) stations are located at 205m and 217m from IP1, respectively; while the Patch Panel (PP, lower right photo) is located at 212m from IP1.

Figure 2 shows projected radiation levels at the end of Run-3 proton-proton physics (working distance, ~40cm) for LSS1 [4]. As one can see from Figure 2, the AFP detector is affected by radiation coming from TCL6 collimators in LSS1, which are the hottest in terms of radiation levels in the area. AFP FAR station is particularly impacted, which is located ~1m upstream of TCL6.

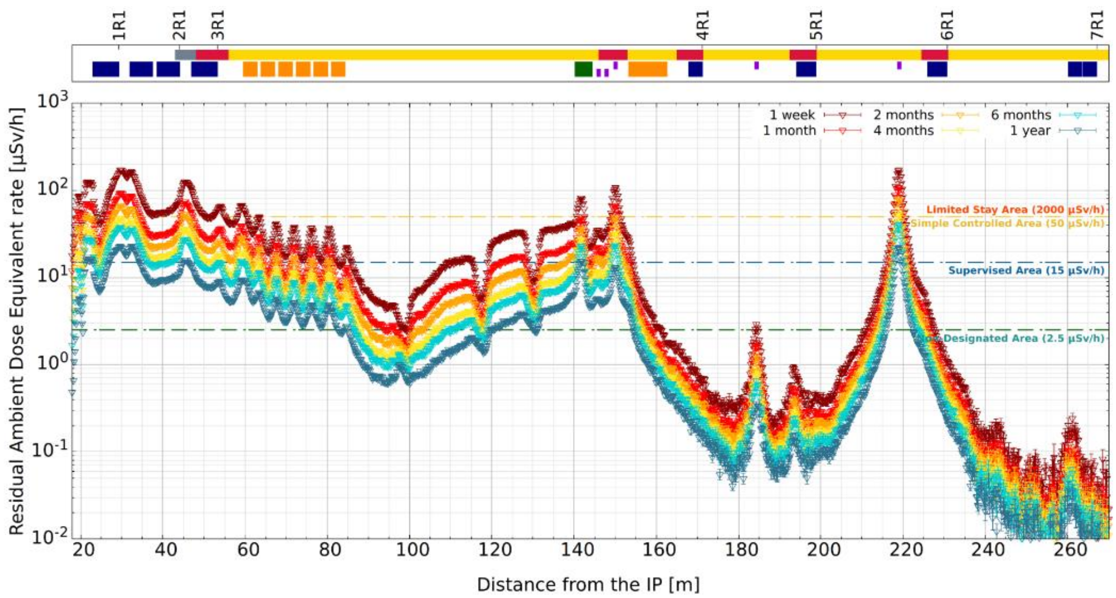

Figure 2 - Projected radiation levels at the end of Run-3 proton-proton physics (working distance, ~40cm) for LSS1.

2. REASON FOR THE CHANGE

In 2023, very tight TCL6 settings were applied, which negatively affected detector operation. To mention: difficulties (sometimes impossibilities) to perform detector calibration during inter-fill periods, significant increase of the failure rate of the electronics components and radiation dose acquired by the AFP team members performing necessary interventions during short accesses. Hence, an urgent shielding solution was needed to be promptly implemented during TS1, which noticeably reduced operational issues and component failure.

This change was critical to continue detector operation and mitigate high failure rate of components due to high radiation exposure. Without this shielding, AFP risked depleting its spares inventory and incurring frequent short access requirements, leading to increased downtime and operational inefficiency.

3. DETAILED DESCRIPTION

To minimize radiation damage as much as possible, and to reduce the AFP electronics failure probability, small shielding walls were proposed to be installed during TS1 in 2023 for the equipment inside the Patch Panel (VREG Controller Card and VREG Voltage Boards) which was breaking down at an increased pace and for which AFP had very limited spares. A quick solution, suggested by BE-EA-DC and accepted by EN-ACE-INT, was to use iron bricks of 20x10x10cm in size, for relatively easy manipulation and installation. A proposed solution for the Patch Panel is shown in Figure 3.

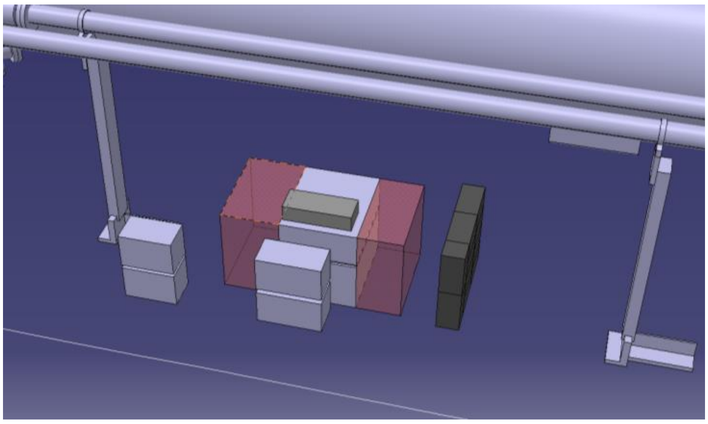

Figure 3 — Small shielding wall integration model for the AFP Patch Panel.

The solution was presented at the ICL meeting on 14.06.2023, accepted by LHC Integration and Coordination group representatives and finally the intervention was approved and validated by the LMC on the same day [5]. The shielding bricks were promptly prepared by BE-EA-DC and installed on 22.06.2023 during TS1. In the very end, used a total of 8 bricks per wall/side, consisting of two columns (2x4), as shown in Figure 4.

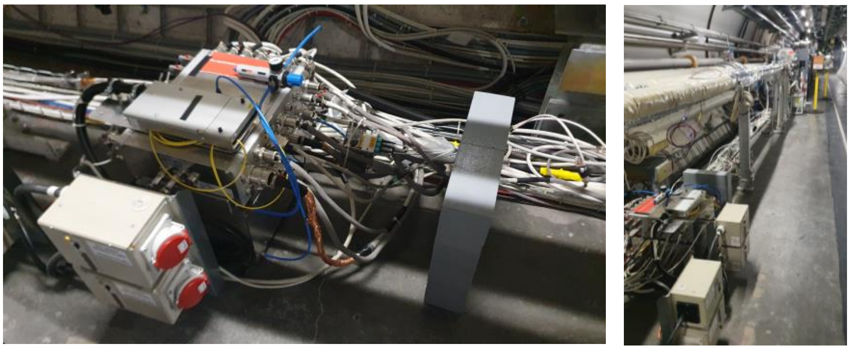

Figure 4 – Photos of installed small shielding wall in LSS1L

Another shielding wall was needed to protect AFP electronics in the so-called ToF crate located on the floor ~1 m from the TCL6. Due to limited space, there were strong constraints regarding available volume for any shielding wall – the solution must assure access to the TCL6, TE-VSC group equipment and BPM (see Figure 5), all of which had to be taken into account. Due to these limitations, it was suggested not to proceed with the small shielding wall installation next to TCL6.

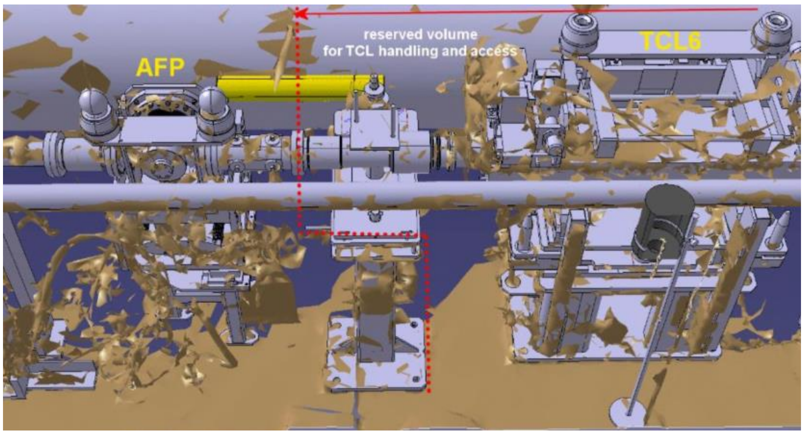

Figure 5 – Layout between AFP and TCL6 in LSS1L

Fortunately, the AFP request to relax the TCL6 settings (from ~1.6mm to ~2mm) was accepted resulting in no significant issues observed in either ToF or PP equipment.

In 2024 however, TCL6 settings were set even tighter than initially in 2023 in order to ensure lower radiation damage and noise to other equipment (R2E) and experiments (SND, FASER) around IP1. This caused frequent failures of the AFP electronics, predominantly in the ToF crate and PP. Since it was not possible to relax the TCL6 settings this time, possibility to have a shielding wall between the ToF crate and the TCL6 was re-examined.

After in-situ inspection by EN-ACE-INT during TS1, a small space was identified just enough to install a similar shielding wall to the one for PP. It was also suggested to increase the height of the PP small shielding wall by additional 1 row of 2 bricks. Thanks to prompt approval by EN-ACE-INT/ISS and swift reaction by BE-EA-DC to supply additional bricks, the AFP was able to install the additional small shielding walls for the ToF crates on both sides (2 x 13 bricks each) and add one more layer of bricks (2) to increase the height of the PP shielding walls [6]. Figure 6 shows the integration model and how the shielding walls look like after installation and as they stand at the moment.

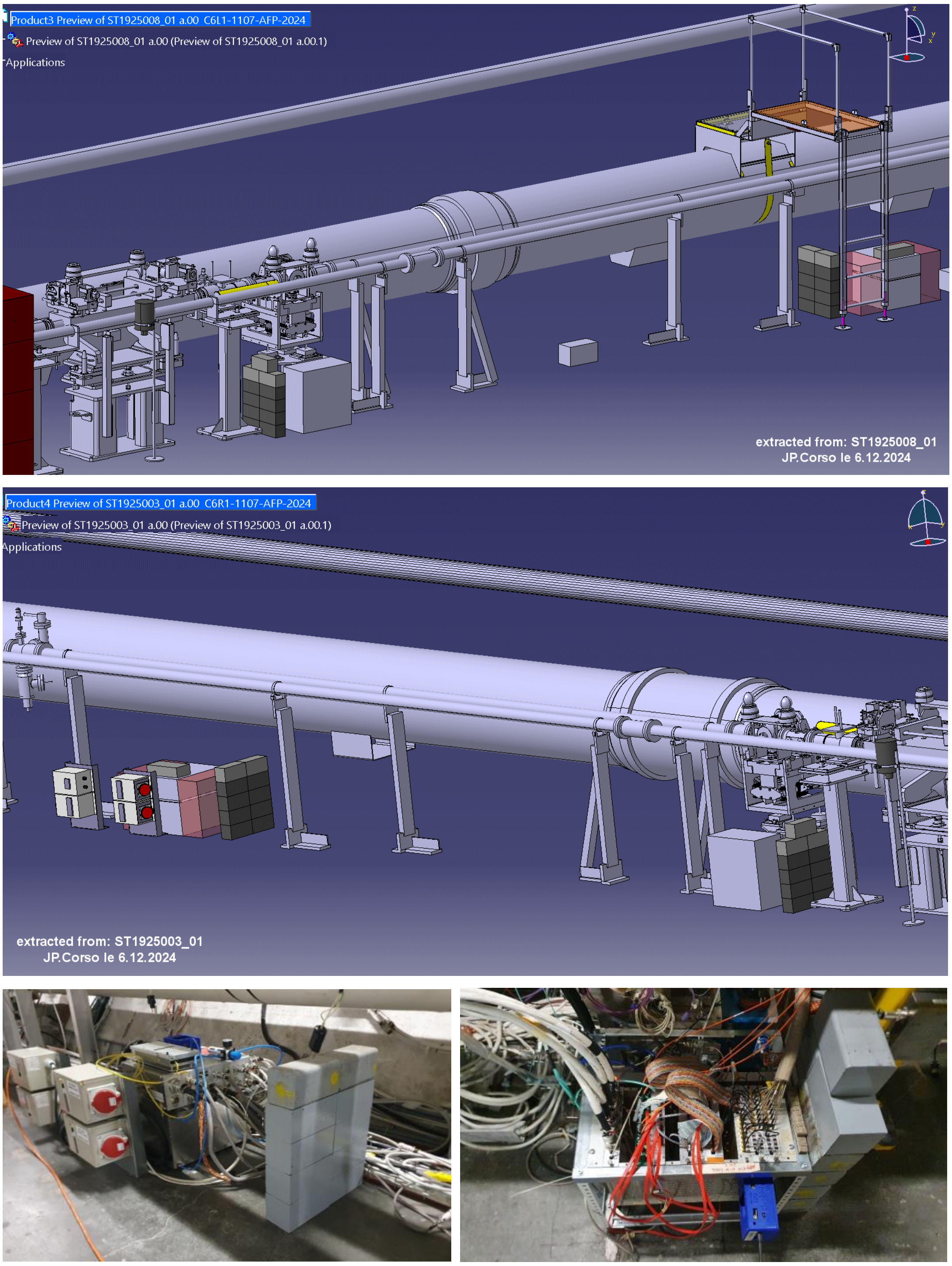

Figure 6 – Small shielding walls (integration model and photos) in LSS1.

In addition, radiation monitors (BatMons, located in the blue boxes) were also promptly installed by BE-CEM-EPR on the ToF crates and the patch panels to follow up on the shielding effect and experienced radiation levels.

Installed small shielding walls/iron bricks should remain until the end of Run-3, *i.e.* the end of AFP data-taking. In case of any issues or particular requests, they can be removed at any point during short access within 1h as the bricks are very easy to manipulate and transport.

4. IMPACT ON OTHER ITEMS

4.1 IMPACT ON ITEMS/SYSTEMS

Item/System xxxxx	None
Item/System xxxxx	

4.2 IMPACT ON UTILITIES AND SERVICES

Raw water:	None
Demineralized water:	None
Compressed air:	None
Electricity, cable pulling (power, signal, optical fibres…):	None
DEC/DIC:	None
Racks (name and location):	None
Vacuum (bake outs, sectorisation…):	None
Special transport/ handling:	No special transport needed as bricks are easily manipulated and can be transported using a push bar trolley.
Temporary storage of conventional/radioactive components:	The blocks are registered in TREC to allow traceability from the RP group [CR-160582].
Alignment and positioning:	None
Scaffolding:	None
Controls:	None
GSM/WIFI networks:	None
Cryogenics:	None
Contractor(s):	None
Surface building(s):	None
Integration:	ST1925008_01 a.00 C6L1-1107-AFP-2024 ST1925003_01 a.00 C6R1-1107-AFP-2024
Others:	None

5. IMPACT ON COST, SCHEDULE AND PERFORMANCE

5.1 IMPACT ON COST

Detailed breakdown of the change cost:	None
Budget code:	T577200

5.2 IMPACT ON SCHEDULE

Proposed installation schedule:	TS1 in 2023 and TS2 in 2024.
Proposed test schedule (if applicable):	None
Estimated duration:	1h
Urgency:	Very high
Flexibility of scheduling:	Flexible with the removal date, however aiming for asap upon end of AFP program.

5.3 IMPACT ON PERFORMANCE

The lifetime of AFP system strongly depends on having these small shielding walls in place. It will help keep the detector and its electronics operational in the LHC tunnel until end of Run-3.

Mechanical aperture:	[To be completed with BE-ABP and/or SY-ABT. Consider injection, extraction, top energy, resonant excursion, when applicable.]
Impedance:	[To be completed with the impedance team (BE-ABP, SY-RF). Check the longitudinal and transverse contributions to minimise beam induced heating and instabilities. In case of potential impedance issues asses the need of: damping resistors (SPS), ferrites (SPS or LHC), coating, tapered transitions… Consider the full integration of the device in the existing beam line (transitions, bellows and insulation).]
Optics/MADX	[To be completed by BE-ABP.]
Electron cloud (NEG coating, solenoid…)	[To be completed with BE-ABP and/or TE-VSC.]
Insulation (enamelled flange, grounding…)	[To be completed with SY-RF. Detail insulation requirements. Consider the EMC/EMI aspects of the installed device.]
Vacuum performance:	[To be completed with TE-VSC.]
R2E impact on performance and availability:	[To be competed with the R2E team for systems with active electronic components to operate in radiation areas. Linked to R2E Radiation Hardness Assurance validation document for concerned equipment (template: EDMS document 2028777)]
Others:	

6. IMPACT ON OPERATIONAL SAFETY

Impact on People Safety:

The installation and use of the shielding wall made of iron bricks pose no direct risks to personnel safety. The ToF crate shielding wall is securely positioned between the supporting yellow pillar and the crate itself, ensuring that it does not obstruct access, egress, circulation, or evacuation pathways. The PP shielding wall is free standing, however it is positioned at a location that ensures no obstruction to routine operations, equipment access, or maintenance activities.

Impact on Environmental Safety:

The modification does not introduce any risks to the environment. The materials used (iron bricks) are stable, non-toxic, and safe for prolonged exposure in the operational environment. It was recommended to use iron rather than lead, following safety guideline SG-C-0-0-3.

Impact on Safety of Operations:

The shielding wall has been installed in a location that does not interfere with routine operations, maintenance, or access to the equipment. Its placement has been reviewed and approved by relevant stakeholders to ensure compatibility with operational workflows.

Risk Analysis:

While the shielding wall has been designed and positioned to minimize hazards, there is a small risk that a brick could fall onto the equipment below, potentially causing damage to that equipment. This risk is considered low due to the stable stacking of the bricks and the confined nature of the installation. AFP has acknowledged and accepted this risk, determining that the operational benefits of the shielding wall (i.e., reduced radiation exposure and component failure) far outweigh this potential drawback. Regular inspections of the shielding walls have been continuously performed over the past year to verify their stability.

Conclusion:

The shielding wall modification has been implemented with careful consideration of operational safety. Its benefits in terms of reducing radiation exposure and extending component lifespan justify the minimal associated risks. No further safety concerns are identified.

6.1 ÉLÉMENT(S) IMPORTANT(S) DE SECURITÉ

Requirement	Yes	No	Comments
EIS-Access		X	
EIS-Beam		X	
EIS-Machine		X	

6.2 OTHER OPERATIONAL SAFETY ASPECTS

What are the hazards introduced by the hardware?	- This are standard iron bricks that CERN uses for shielding purposes and complies with CERN safety rules. - The modification does not introduce any obstruction of evacuation paths.
Could the change affect existing risk mitigation measures?	No.
What risk mitigation measures have to be put in place?	Regular inspections of the shielding walls to verify their stability.
Safety documentation to update after the modification	None.
Define the need for training or information after the change	None.

7. WORKSITE SAFETY

7.1 ORGANISATION

Requirement	Yes	No	Comments
IMPACT – VIC:	X		213384 and 232766
Operational radiation protection (surveys, DIMR…):		X	Shielding installed towards the end of TS1 period, minimizing the absorbed radiation as much as possible.
Radioactive storage of material:		X	
Radioactive waste:		X	The shielding wall next to TCL6 is the most exposed, however most likely it will be reused. The blocks are registered in TREC to allow traceability.
Non-radioactive waste:		X	
Fire risk/permit (IS41) (welding, grinding…):		X	
Alarms deactivation/activation (IS37):		X	
Electrical lockout:		X	
Others:		X	

7.2 REGULATORY INSPECTIONS AND TESTS

Requirement	Yes	No	Responsible Group	Comments

HSE inspection of pressurised equipment:		X		
Pressure/leak tests:		X		
HSE inspection of electrical equipment:		X		
Electrical tests:		X		
Others:		X		

7.3 PARTICULAR RISKS

Requirement	Yes	No	Comments
Hazardous substances (chemicals, gas, asbestos…):		X	
Work at height:		X	
Confined space working:		X	
Noise:		X	
Cryogenic risks:		X	
Industrial X-ray (*tirs radio*):		X	
Ionizing radiation risks (radioactive components):		X	The blocks are registered in TREC to allow traceability by RP. [CR-160582]
Others:			

8. FOLLOW-UP OF ACTIONS BY THE TECHNICAL COORDINATION

Action	Done	Date	Comments
Carry out site activities:			
Carry out tests:			
Update layout drawings:			
Update equipment drawings:			
Update layout database:			
Update naming database:			

Update optics (MADX)			
Update procedures for maintenance and operations			
Update Safety File according to EDMS document 1177755:			
Others:			

9. REFERENCES

[1] ATLAS Collaboration, "Technical Design Report for the ATLAS Forward Proton Detector", CERN-LHCC-2015-009, ATLAS-TDR-024 (2015).

[2] C. Ng, J. Pinfold, M. Rijssenbeek, P. Sicho, "ENGINEERING CHANGE REQUEST – Installation of the ATLAS/AFP stations, Phase-1,", LHC-XAFP-EC-0002, EDMS 1514549.

[3] C. Ng, J. Pinfold, M. Rijssenbeek, P. Sicho, T. Sykora, M.Trzebinski, "ENGINEERING CHANGE REQUEST – Installation of the ATLAS/AFP stations, Phase-2,", LHC-XAFP-EC-0003, EDMS 1705651.

[4] P. Dyrcz, A.Infantino (HSE-RP), "Radiation protection estimates for the operations during LS3", EDMS 2790070.

[5] A. Bardon (EN-ACE-OSS), "Overview on the TS1 activities", LHC Machine Committee (LMC #465) contribution.

[6] M. Milovanovic, "LSS1 – AFP shielding", Reunion ICL (19.06.2024) contribution.