PREPARATIONS FOR THE EXECUTION PHASE OF BDF/SHIP AT THE HI-ECN3 FACILITY IN CERN'S NORTH AREA

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Abstract

The High-Intensity ECN3 (HI-ECN3) Project [1] will upgrade the ECN3 underground experimental area in CERN's North Area (NA) [2], to host the Beam Dump Facility (BDF) [3, 4] and the Search for Hidden Particles (SHiP) experiment [5–8]. The required refurbishment of underground infrastructure and associated surface facilities is scheduled for Long Shutdown 3 (LS3) [9], while installation of BDF and SHiP is foreseen in 2030 and beam commissioning of the BDF is planned in 2031 [10]. HI-ECN3 must share specialised resources during LS3 with other activities in the SPS [11] and the NA, without having priority over them. This makes the coordination and scheduling of limited resources a challenge, particularly during LS3 when the workload will be at its maximum. To reduce these risks, a set of preparatory measures have been implemented ahead of LS3. This contribution details the key preparatory activities and efforts to smooth the demand on resources during LS3 and enhance the readiness of the ECN3 facility for the subsequent installation phase.

INTRODUCTION

The HI-ECN3 project aims to upgrade CERN's NA for the Beam Dump Facility (BDF) and SHiP experiment by dismantling the NA62 experiment during LS3. This paper presents the preparation strategy to execute this phase under resource, radiological, and logistical constraints, using a procedure-driven, resource-aware planning approach based on Work Package Analyses (WPAs) [12, 13] applied to LS3 Baseline 0 [14]. The results demonstrate early identification of critical operations, resource conflicts, and execution constraints, enabling a realistic dismantling sequence and improved readiness for the installation phases.

HI-ECN3 FACILITY AND INFRASTRUCTURE UPGRADE

To enable the installation of the Beam Dump Facility (BDF) and the SHiP experiment, the ECN3 and TCC8 facilities, located at the end of the P42 beamline in the North Area (Fig. 1), [15], must undergo substantial infrastructure modifications. The North Area is the largest experimental area and extracts its beam from the SPS complex [16, 17].

These modifications include the dismantling of the current experimental setup (Fig. 2a), the installation of the SHiP configuration (Fig. 2b), upgrades to beam transport systems, radiation shielding, machine protection, and cavern layout.

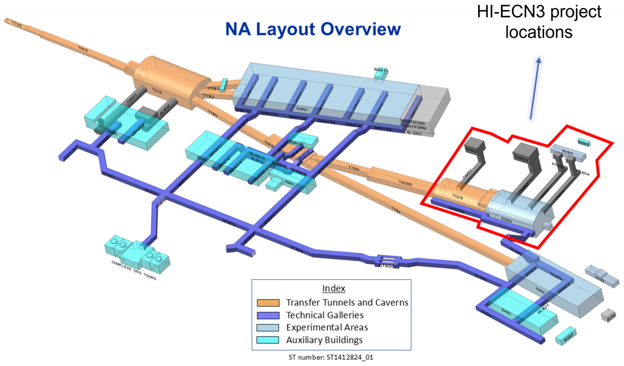
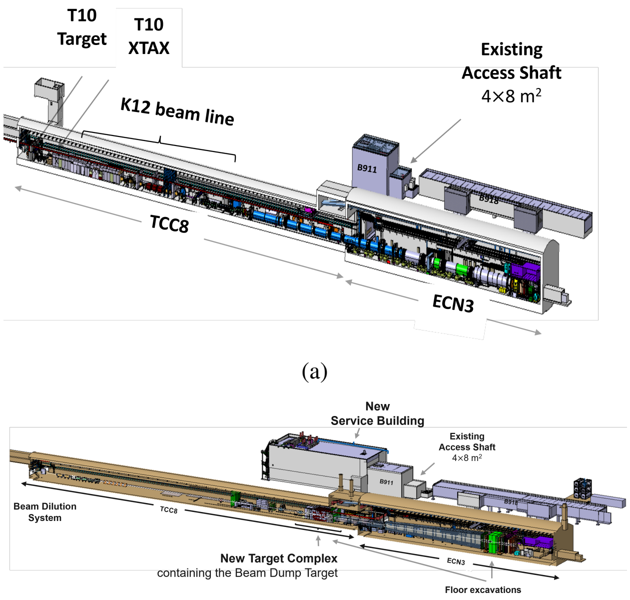


Figure 1: TCC8 and ECN3 location in CERN's North Area

In addition to underground works, significant surface infrastructure modifications are required. A new service building will be constructed next to building 911 to host systems supporting the BDF target complex [18], including cooling, electrical distribution and control systems. The design also foresees provisions for remote handling and dismantling of activated components, driven by the expected high-radiation environment.



(a)

(b)

Figure 2: TCC8 and ECN3 cavern integration: (a) current configuration, (b) configuration after the installation of the BDF and SHiP experiment

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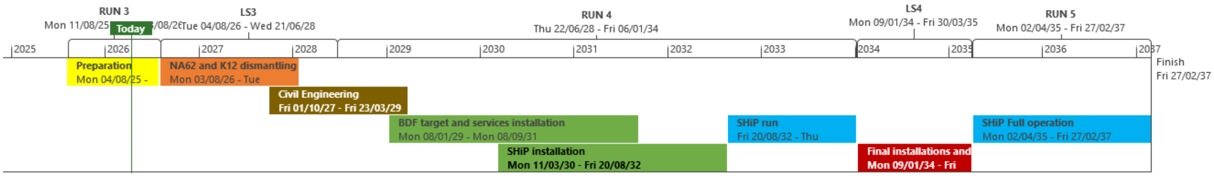

Figure 3: HI-ECN3 project phases aligned with CERN operational periods

PROJECT EXECUTION CONTEXT AND LS3 CONSTRAINTS

The HI-ECN3 project spans CERN's Accelerator Schedule [19], [9] Run 3, LS3, Run 4, LS4, and Run 5, following a phased approach aligned with operational periods [10], as shown in Fig. 3.

- **Preparation phase**: During late Run 3 (2025–2026), early infrastructure adaptations were made, including a concrete platform for the LKr dewar from ECN3 [20].
- **Dismantling phase**: LS3 (2026–2028) focuses on NA62 and K12 dismantling [15, 21], infrastructure removal, and civil-engineering works to prepare for BDF and SHiP installation.
- **Installation & commissioning**: Following LS3, the installation of the BDF target system and associated services is carried out during Run 4, enabling the commissioning of the high-intensity beam. The installation of the SHiP detector begins once beam delivery has been validated giving 1 year of operation during Run 4. It continues through LS4, leading to full operation during Run 5.

LS3 is critical due to its technical complexity, radiation constraints, and shared resource limits, requiring dedicated preparation for efficient execution and readiness for later phases.

LS3 PREPARATION AND EXECUTION STRATEGY

The preparation for LS3 constitutes the core contribution of this work. It is based on a detailed, procedure-driven planning methodology combined with resource integration, logistical optimisation and radio-protection (RP) control [12] .

The HI-ECN3 worksite is classified as a Category 1 [22] site at CERN, implying a high level of risk of co-activity and operational complexity. This classification requires formal safety coordination, dedicated safety documentation and strict control of all activities, further increasing the need for detailed planning and coordination.

WPA–Driven Planning and Coordination

The LS3 planning is based on a Work Package Analysis (WPA) approach, in which each system in TCC8 and ECN3 is studied through dedicated dismantling procedures. This standard CERN method for non-routine operations defines activities at a granular level.

Each WPA includes a step-by-step description, the required supporting groups, and the relevant safety and radioprotection requirements, with specific input from RP teams. These documents are the basis for a detailed and reliable project schedule.

A weekly *Planning (Installation) and Dismantling Coordination* meeting is used to present, review, and validate each WPA with all stakeholders. Once approved, the WPAs are stored in CERN Engineering & Equipment Data Management System (EDMS), while planning updates are regularly shared to identify constraints, assess resource availability, and keep all groups aligned.

Resource-Loaded Planning and Logistics Constraints

Given the high workload during LS3, the planning explicitly integrates human and equipment resources. Key personnel include the Transport and Handling Engineering group (EN-THE) teams for crane operation and transport [23], the Detector Technologies group's (EP-DT) technicians for dismantling support [24], and NA62 experts for detector removal.

Critical equipment such as the TCC8 and ECN3 cranes, the transfer trolley, the shaft, and a permanent underground cherry picker are treated as shared resources in the planning. This allows potential conflicts to be identified and resource use to be optimised.

Logistics represent a major constraint due to the limited storage capacity in building 911. Dismantled components must be evacuated immediately after release, requiring precise coordination with transport services. Items to be reused by SHiP have also been integrated into the planning, including underground storage, surface transfer, and container allocation.

Radiation Constraints and Critical Dismantling Activities

Radiation is a key constraint for LS3 operations. The activated environment requires all dismantling activities to follow strict radioprotection procedures, and the Radiation Protection group's (HSE-RP) [25] studies have provided radiological activation level estimates according to materials and locations.

All components must be surveyed before removal. Although the background radiation is relatively low in some areas and it allows in-situ measurements, in some other areas it still limits access, intervention time, and activity sequencing.

The dismantling of the highly activated T10 target area upstream of TCC8 is one of the most critical operations. It is carried out in coordination with CERN's Nuclear Dismantling Contractor (NDC), taking advantage of their availability between TCC2 operations within the NA-CONS project frame [26].

The dismantling procedure has been developed down to individual shielding blocks. An As Low As Reasonably Achievable (ALARA) level 3 [27] approach is applied, with dedicated reviews, detailed planning, and dose optimisation to ensure safe execution.

LS3 BASELINE PLANNING AND EXECUTION SEQUENCE

The LS3 dismantling planning has been consolidated into an initial baseline, Baseline 0 [14]. This baseline defines the first execution sequence of activities based on the Work Package Analyses and reflects the main operational, safety, and logistical constraints identified during preparation. After validation, stakeholder comments, and confirmation of team and resource availability, an updated Baseline 1 will be issued to further refine the execution strategy.

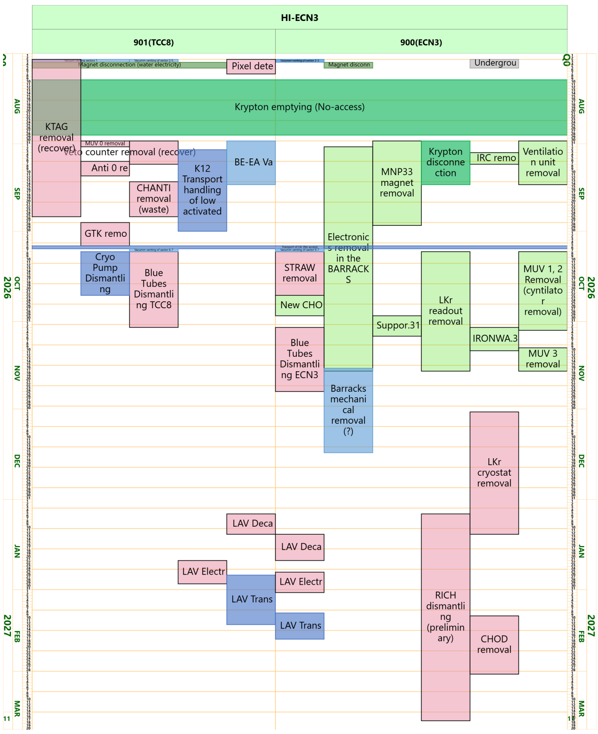

Figure 4: Baseline 0 LS3 dismantling planning for the NA62 experiment and associated infrastructure [14]

The main objective of the dismantling phase is to leave the cavern as empty as possible, creating optimal conditions for the subsequent civil-engineering and installation works. Figure 4 presents a Gantt chart of the dismantling sequence.

1. *Start of the Removal*: Sequence starts post-beam with vacuum/magnet disconnection for safe magnet/detector removal.

2. *Liquid Krypton evacuation:* A key safety constraint is the removal of the LKr from the calorimeter, which has been installed in the cavern for approximately 30 years. It needs to be transported before the start of any works around it.

3. *Dismantling of the NA62 detectors and K12 equipment:* Detector removals detailed in WPA docs; cables marked with purple tags for de-cabling.

4. *De-cabling:* Full de-cabling campaign removes identified in the Demande Enlevement de Cables (DEC) and "orphan" cables to empty cavern.

5. *The TCC8 crane replacement:* Upgraded crane essential for activated components; must precede T10 dismantling.

6. *T10 target dismantling:* The most critical part of the dismantling activities concerns the T10 target area upstream of TCC8, which is highly activated. The removal of this area is performed under strict radioprotection conditions and follows a detailed procedure developed within the TCC8 removal Work Package [28]. The operation is coordinated with the Nuclear Dismantling Contractor (NDC), whose activities are primarily focused on the dismantling of the TCC2 [29, 30] cavern within the NA-CONS consolidation framework.

Logistical constraints, particularly limited storage in building 911, require immediate evacuation of dismantled components, demanding precise coordination with transport services and a tightly controlled sequence.

Overall, Baseline 0 [14] provides a structured, realistic LS3 execution framework, capturing key constraints and interfaces to enable progressive planning refinement.

CONCLUSION

The preparation of LS3 activities for the HI-ECN3 project demonstrates the importance of detailed, procedure-driven planning in complex, resource-constrained environments.

The combination of Work Package–based planning, integrated resource management, and proactive mitigation of logistical and radiological constraints enables a controlled execution of dismantling activities and ensures the readiness of the facility for subsequent installation phases.

This approach highlights the critical role of early coordination and risk mitigation in large-scale accelerator infrastructure projects, particularly when operating within tightly constrained schedules such as CERN long shutdown periods.

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