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EDMS NO.	REV.	VALIDITY
3014858	**3**	**UNDER APPROVAL**

REFERENCE

CONTROLS CHANGE REQUEST

LHC Beam Dump System
REMOTE TEST-MODE

BRIEF DESCRIPTION OF THE PROPOSED CHANGE(S):

This control change request describes the software modification, test and validation performed for the slow control and the remote applications deployed during the YETS#23-24, allowing the start of test mode functionalities remotely for the LHC Beam Dumping system.

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1. INTRODUCTION

Three operational parameters determine the performance of the extraction kicker system: its state, kick time and kick strength. To reflect this, its control architecture comprises three independent sub-systems, each one dedicated to the control of one specific parameter:

- The State Control and Surveillance System (SCSS),
- The Trigger Synchronization and Distribution System (TSDS),
- The Beam Energy Tracking System (BETS).

The SCSS is based on the fail-safe multi-programmable logic controller (PLC) architecture. It ensures the control of states of the global machine and individual subsystems, always including safety functions for the machine and worker protection. This SCSS integrates test functionalities for ABT experts to perform checks on magnets, HV generators, and the control system.

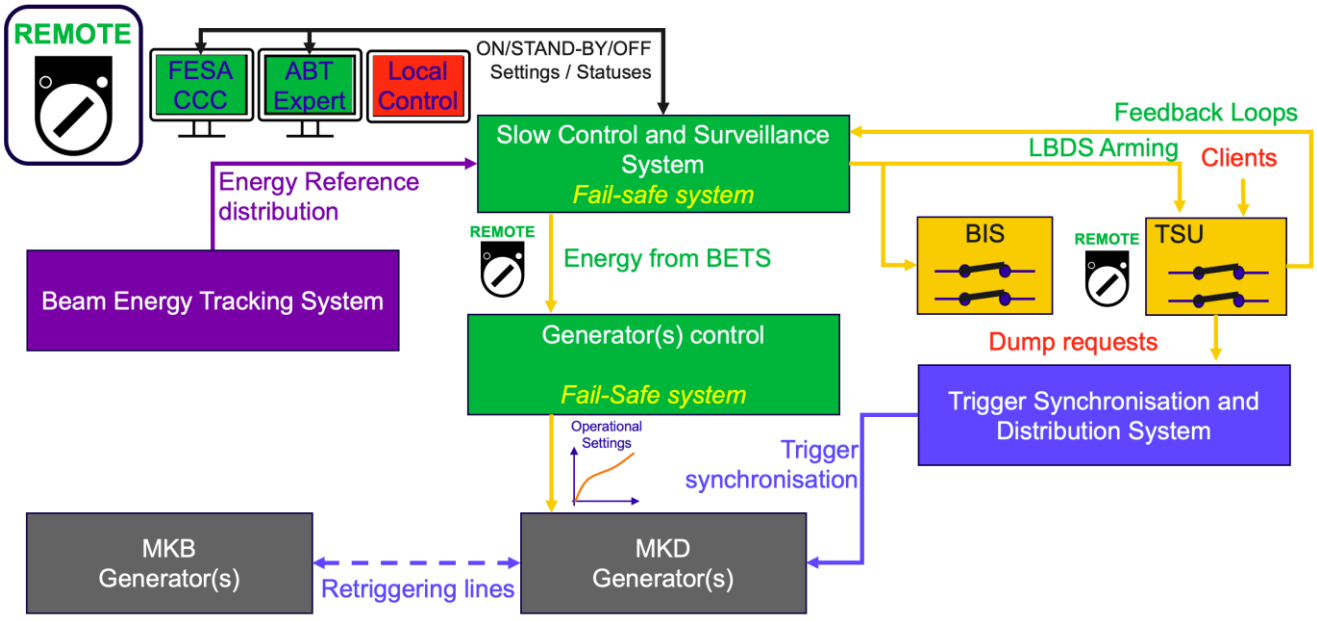


Figure 1 - Simple overview of the LBDS control systems in operation

For more detail and information, see the slides of the MPP of 17th November 2023. [1]

The LBDS LOCAL/REMOTE control mode is defined by an L/R switch located in P6.

The main differences between these control modes are summarised in Table 1 - LOCAL/REMOTE Control repartition.

Table 1 - LOCAL/REMOTE Control repartition

L/R mode	LOCAL control	REMOTE control
SCSS **Control source**	From the LOCAL panel only	From Expert GUI or FESA only
TSDS **Trigger source**	TSU LOCAL trigger input is connected to PLC.	TSU clients dump requests.
BETS **Energy reference for HV generators**	Coming from PLC during/for the test sequences	Coming from BETS

The LBDS test sequences allow the (re)validation of the MKD/MKB generators and magnets installed in point 6 of the LHC (UA63/67) using different test modes controlled by the local panel application:

1. Pulse Generator
2. Energy scan
3. Operation Cycle generation
4. Retriggering generation
5. Sparking Activities generation

These Test sequences are only available when the system is set to LOCAL control mode and can only be executed from the LOCAL control panels in Point 6 UA63/67.

This is constraining as it forces us to access P6 to switch to LOCAL to perform tests.

During YETS23-24, we implemented the possibility of executing these test sequences remotely while the system was in REMOTE control mode. This requires some changes in the PLC code.

It should be noted that this remote test mode does not use the 'BETS simulator', where Beam Energy Measurement (BEM) cards are disconnected from LHC main bends DCCTs and connected to a simulator that we can control to fake operational ramps during shutdowns. In remote test mode, the energy distributed to the HV generators is controlled by the LBDS PLC, but BETS is still connected to the LHC main bends.

This document details the following points on the safety and functional aspects identified as the deployment condition during the YETS 2023-2024.

1. Risk assessments of the solution proposed and compensation measures;
2. Safety modification and validation assurance;
3. Software modification and validation process;
4. Acceptance tests – checklist;
5. Local Reliability Run (LRR)– test condition;
6. Remote Reliability Run (RRR) – test condition.

2. MOTIVATION FOR CHANGES

The LHC Beam Dumping System integrates several test sequences to ensure the (re)validation of the system's integrity and calibrate the numerous parameters of the LBDS control systems.

These test sequences are executed during the Local Reliability Run (LRR) period to simulate energy cycles or pulse the system at specified energies to calibrate and validate LBDS parameters. For instance, they are also used during operation to recondition a magnet after an HV breakdown or an HV generator after a self-trigger.

Presently, these functionalities are only authorised in LOCAL control mode.

During the Remote Reliability Run (RRR) or normal operation, the system is switched to REMOTE control mode. If an ABT expert needs to investigate magnet or HV generator issues, access is required to switch the LBDS to LOCAL controls mode to start the system validation/check.

The principal motivation for the LBDS experts to perform these functionalities remotely are:

- Significant reduction of access requests for maintenance or intervention in operation;
- Magnet (re)conditioning in case of an HV breakdown;
- Generator (re)conditioning in case of erratic triggering or sparking;
- Alive validation of Sparking Acquisition Monitoring (SAM) application and acquisition channels;

This change also allowed test sequences to be automatically executed by OP or LHC sequencer in the future, for instance, during ramp-down. When it is implemented, OP will discuss this in more detail.

3. DESCRIPTION OF CHANGES

The changes in the LBDS control systems concern:

1. The logic of the LOCAL/REMOTE mode;
2. The enabling of remote test mode by safety logic;
3. Force TSU cards to LOCAL control;
4. The test mode command and the test sequences parameters in SILECS communication with FESA;
5. The test mode interface between the SCSS and the new FESA class deployed.

In the following sub-chapters, we'll describe the principal changes impacting the safety and respond to each requirement defined in the MMP meeting.

3.1 SCSS CHANGES

The principal modification concerns the SCSS software, which regroups the safety and functional functionalities to operate the LBDS and allows the launch of the test sequences in safe conditions locally. Two changes have been applied to the low-level software to authorise the start of test mode remotely.

The TEST mode is called SIMU or simulation mode in the PLC code below.

For safety, the changes concern:

1. Change the logic of LOCAL/REMOTE by the safety controller,
2. Insert new safety logic authorising the test mode enabling (detail in Figure 2):
    - **AND NOT** Beam permitted;
    - **AND NOT** Injection Permit;
    - **AND NOT** LBDS system ready;
    - **AND NOT** Trigger Synchronisation Unit (TSU) ready;
    - **AND NOT** TSU locked;
    - **AND NOT** SCSS ready;
    - **AND** Safety activated without discrepancy/passivation;
    - **AND** Main power ready (Power switch OFF or lost);
    - **AND** Loop voltage Surveillance (LVPS) of safety elements are activated;
3. Adapt the safety logic for the LOCAL/REMOTE of the TSU and CIBDS modes:
    - CIBDS switch in LOCAL when test mode is enabled by safety logic
        - ARMING loop opened, blocking LBDS re-arming
    - TSU switch in LOCAL when the following conditions are present
        - SCSS in LOCAL;
        - SCSS in REMOTE with test mode enabled by safety logic.

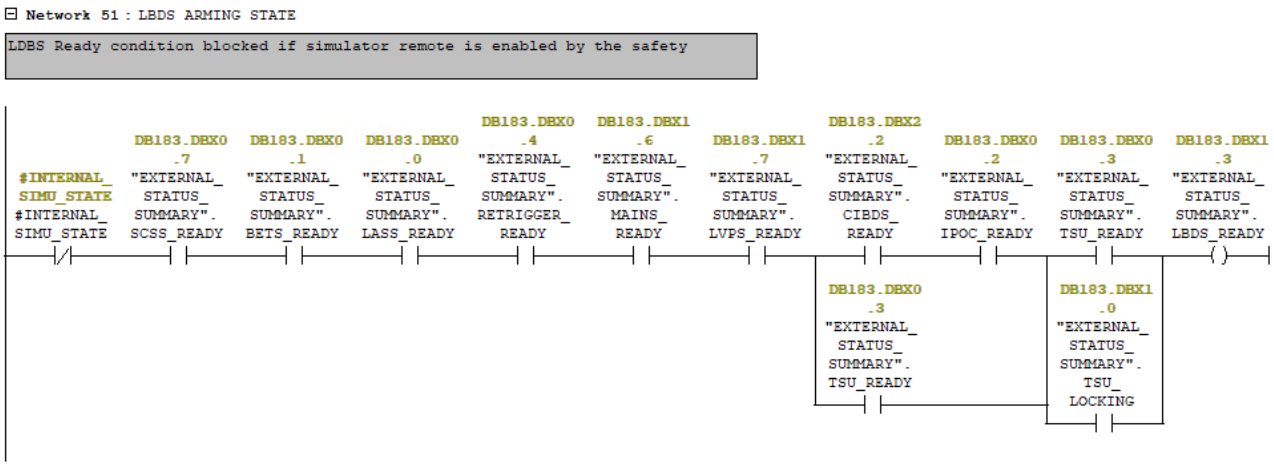


Figure 2 - Logic implemented in low-level guaranteeing to enable based on safe conditions

For the functional, the changes concern:

1. SCSS local control blocked during active test mode in remote,
2. Modify of LOCAL/REMOTE mode software propagation,
3. Add a new condition for test mode enabled (see **Error! Reference source not found.**)
    - Local mode (no change)
    - Remote mode and test mode enabled by safety logic
4. Insert a new instance of parameters for the remote test mode from the FESA class.

No modification is required for the test sequences' functionalities themself to allow them to work in REMOTE control mode. New acquisition blocks should be added, and new parameterising should be provided with the FESA interface.

The expert WinCC GUI displays the status of the test mode (Figure 3)

ABT will also update the fixed display to show the TEST mode status.

The FESA class will also provide the status of the TEST mode, as explained in the following chapter.

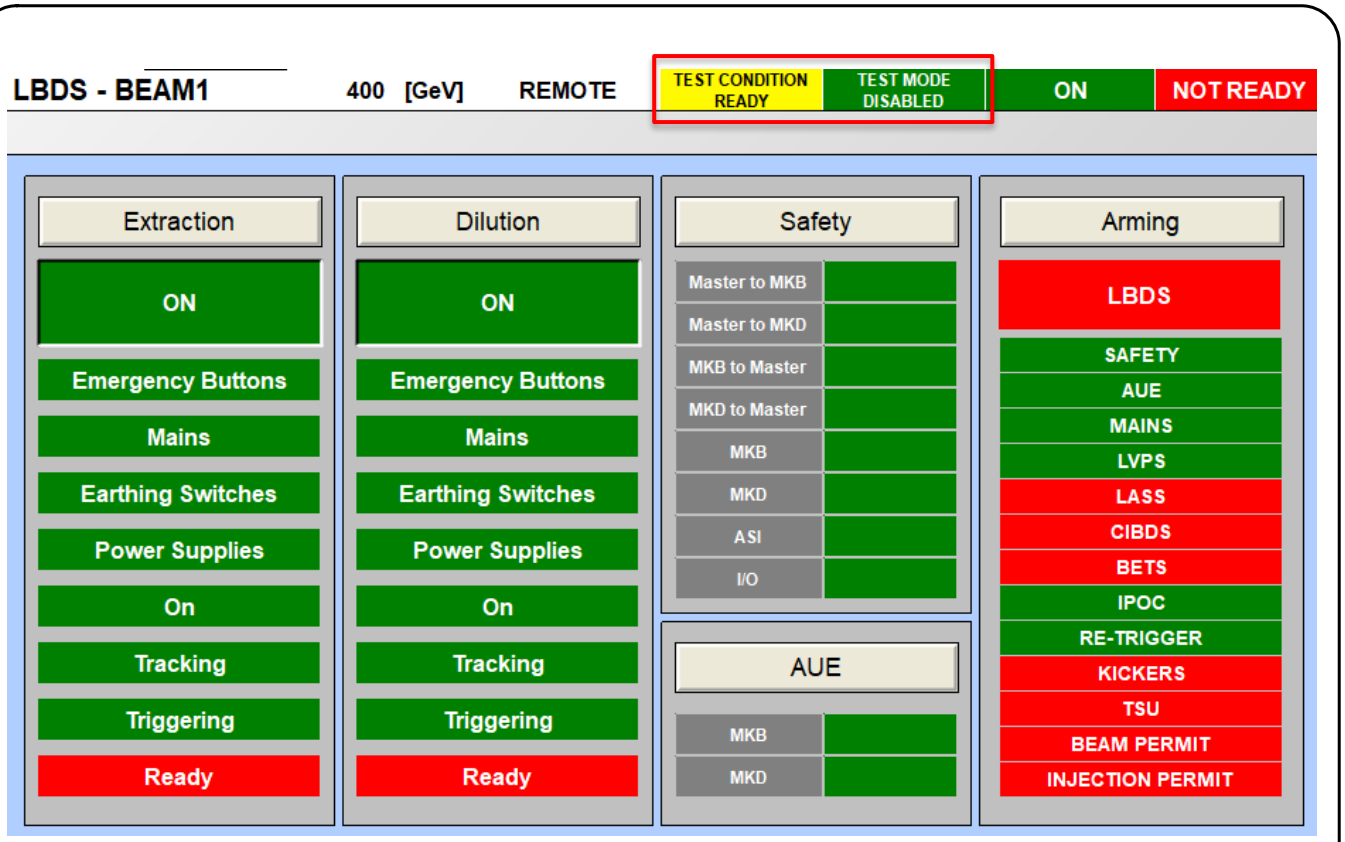


Figure 3 - GUI for the remote control by ABT experts

3.2 FESA class update

3.2.1 Existing LhcLBDSkicker FESA class

As shown in Table 3 – The LhcLBDSState device names for each beam., a new status field was added to the existing FESA class to inform about the state of test mode.

Class	Property	Field	Comment
LhcLBDSkicker	Status	testModeEnabled	True if remote test mode is enabled.

Table 2 – The field added to the LhcLBDSkicker FESA class

LBDS	Beam 1	Beam 2
Device	LBDS.UA63.STATE.B1	LBDS.UA67.STATE.B2

Table 3 – The LhcLBDSState device names for each beam.

3.2.2 New AbtTestSeqCtrl FESA class

This chapter outlines the key design aspects of the remote test sequence controller, detailing the specific functionalities and checks associated with each property.

A new FESA class 'AbtTestSeqCtrl' is deployed to control test mode remotely. The class exposes command properties to enable, start, stop, and disable the test mode.

LBDS	Beam 1	Beam 2
Device	LBDS.UA63.TESTSEQ.CTRL.B1	LBDS.UA67.TESTSEQ.CTRL.B2

Table 4 – The AbtTestSeqCtrl device names for each beam.

Property	**RBAC Role**	**Operation**	**Location**
TestModeAuthorisation	LHC-Operator	Operation	CCC-LHC
TestModeAuthorisation	BT-LBDS-Expert	Non-Operation	
EnableTestMode	BT-LBDS-Expert	Always	
DisableTestMode	BT-LBDS-Expert	Always	
StartTestSeq	BT-LBDS-Expert	Always	
StopTestSeq	BT-LBDS-Expert	Always	

Table 5 – Controller FESA Class Properties and RBAC Configurations

TestModeAuthorisation (Setting Property):
This property includes the "isTestModeAuthorised" field, which enables OP to allow or disallow the remote test mode on LBDS. The authorisation can be revoked when the test mode is disabled.

EnableTestMode (Command Property):
Enables the remote test mode. It's possible to enable the remote test mode only if the OP authorisation is given and LBDS is not armed. It's impossible to arm the LBDS if the remote test mode is enabled.

DisableTestMode (Command Property):
Disable the remote test mode and put LBDS back to normal REMOTE operation.

StartTestSeq (Command Property):
Starts the selected test sequence. It's possible to start a test sequence only if the test mode is enabled, so LBDS is not armed. It will not enable the remote test mode automatically if disabled.

StopTestSeq (Command Property):
Stops the ongoing test sequence.

4. IMPACT ON OTHER ITEMS

4.1 IMPACT ON OTHER CONTROLS ITEMS/SYSTEMS

SCSS	FB20 (F_LBDS_CTRL) modified for the L/R and simulation enabling. F-CRC before modification: A9F0 / after modification: 81D2 FC154 (F_LBDS_ARMING) improvement safety compare
FESA	LhcLBDSkicker v1.6.0 deployed to add test mode status. A new FESA class for the remote test mode control (AbtTestSeqCtrl v1.0.0)
SAFETY signature	LBDS Safety functionalities Before modification: 7D211479 After modification: DF74AF47
OP applications	No operational changes A sequence to be adapted to integrate simulation check-out remotely
External inputs (timing signals, etc.)	-

4.2 IMPACT ON BE-CSS (or CEM) UTILITIES AND SERVICES

Hardware installation	-
OASIS	-
Video distribution	-
Timing system (central & local)	-
CMW proxies & gateways	-
UCAP	-
RBAC rules and access maps	New RBAC to authorise the start/stop of the LBDS test mode
InCA/LSA	-
Logging	-
FixDisplay	New information will be displayed for the LBDS test mode state at all times
CESAR	-
PostMortem	-
Sequencer	-
SIS	-
CCDB (migration, other)	-
Generic user interfaces (WorkingSets, Knobs, LSA app suite, etc.)	-
Expert user interfaces	WinCC expert applications (SY-ABT) update to display the test mode.
CCM	-
Other	-

5. DEPLOYMENT STRATEGY

To allow the deployment of the LBDS simulator functionalities remotely, SY-ABT is scheduled to deploy the changes during the three Important LBDS activities and tasks listed in the YETS planning detail in Figure 4.

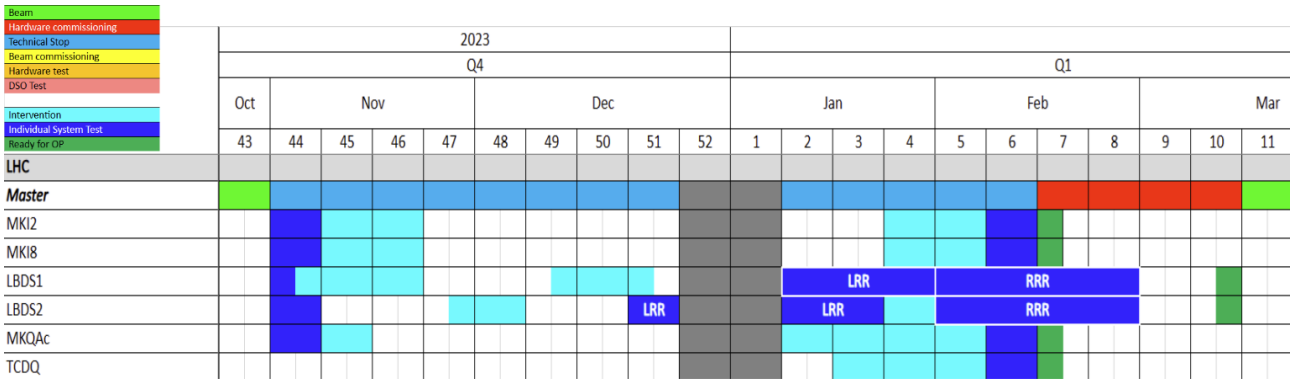


Figure 4 - YETS#23-24 - LHC Planning of SY-ABT

5.1 DEPLOYMENT PLANNING

The functional test will be performed during the intervention period, from **weeks 49 to 51 in 2023**. The SCSS software will be tested, and changes will be deployed before W50. The new FESA interface will be tested individually during the intervention period.

The LBDS revalidation will be performed in two phases:

1. Local Reliability Run (LRR): The LBDS is pulsed locally to revalidate all sub-systems, acquisitions, and protections – **weeks 2 to 4 in 2024.**
    a. During this period, the test sequences are revalidated to ensure no dysfunction appears with the remote changes in local
2. Remote Reliability Run (RRR): The LBDS test mode will be tested and validated during this period with remote conditions, **weeks 5 to 8 in 2024**.
    a. During this period, the new FESA interface and the test mode control are validated, along with associated protections in remote

5.2 QUALITY ASSURANCE PLAN & DEPLOYMENT TEST PROCEDURE

The deployment test procedure requires **SY/ABT** to perform and validate the expected behaviour of all components by trying to push the system towards valid and invalid transitions from different states by using various input channels as listed below:

List of checks to be done	Test Result	Responsible Group	Comments
When LBDS is DISARMED & SIMULATOR is DISABLED – Check		SY-ABT	**Initial condition:** **- Parameters valid** **These test points have been performed and validated successfully in remote conditions.**
✓ It is impossible to enable remote test mode	✓		
✓ It is impossible to enable/start the test mode on the local GUI	✓		
✓ It is impossible to start remote test mode	✓		
✓ It is impossible to enable/start the test mode on the Remote expert GUI (without switching to local)	✓		
When the remote simulator is ENABLED – Check:		SY-ABT	**Initial condition:** **- Test mode enabled** **- Parameters valid** **These test points have been performed and validated successfully in remote conditions.**
✓ The LBDKS can't be armed	✓		
From the remote expert GUI ✓ It is impossible to enable/start the test mode ✓ It is impossible to modify the test mode parameters ✓ it is impossible to stop/disable the test mode	✓		
From the local panel ✓ It is impossible to enable/start test mode ✓ It is impossible to change test mode parameters ✓ It is impossible to stop/disable the test mode	✓		
Remote Control application (FESA) ✓ It is possible to disable remote test mode ✓ It is possible to start a remote test mode	✓		
Simulator states and parameters ✓ Check the parameters between the test mode and values returned to the remote expert GUI and FESA nav.	✓		

List of checks to be done	Test Result	Responsible Group	Comments
When the remote simulator is STARTED – Check:		SY-ABT	**Initial condition:** **- Test mode enabled** **- Parameters valid** **These test points have been performed and validated successfully in remote conditions.**
From the local panel ✓ It is impossible to stop/disable the remote test mode	✓		
From the remote expert GUI ✓ It is impossible to stop/disable the remote test mode	✓		
Remote Control application (FESA) ✓ It is possible to stop the remote test mode ✓ It is possible to disable the remote test mode (the simulator is expected to stop when the last test sequence is finished)	✓		
Simulator states and parameters ✓ Check the parameters between the test mode and values returned to the remote expert GUI and FESA nav.	✓		

The roll-back procedure will be tested to ensure it can be deployed if the simulator detects troubles during the operation phases.

5.2.1 ROLL-BACK PROCEDURE

The deployment requires changes on two functionalities but stays optional:

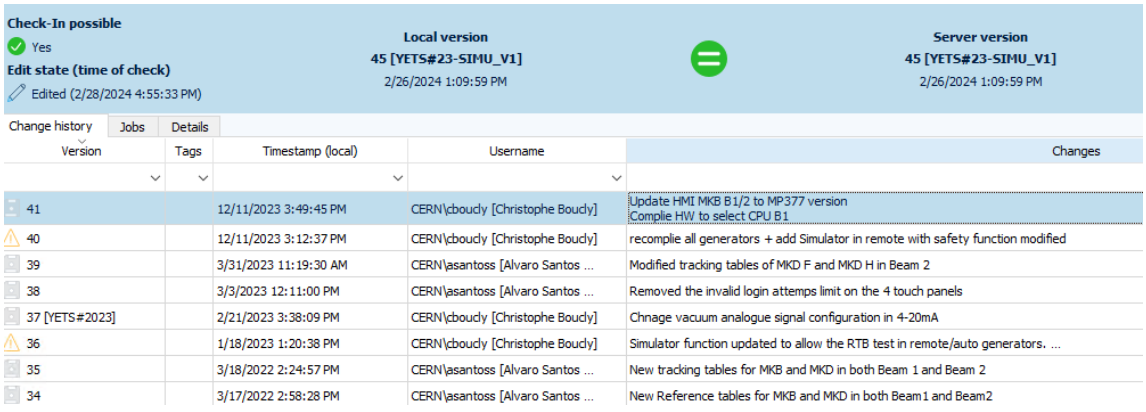
- SCSS: removal of simulator interface and control blocks, allowing the operate the simulator in remote
- FESA: Disabled the deployed unit starting of the simulator class in the front-end

To achieve high flexibility in our roll-back strategy, we aim to create a new data mapping for the simulator part at the middleware level without any modifications or add-ons on the operational mapping for the existing one. In case of deployment failure or perturbance in operation by the simulator function remotely, we have two options concerning the functionalities deployed:

1. Reload the original SCSS Software needing the safety PLC system restart based on the operational version before modification (version 41 of 12/11/2023);
2. Keep safety PLC modification with software deactivating remote simulator conditions by parametrising.

For the FESA class, there is no impact on operation if the property continues to publish. The deactivation or PLC reloading is sufficient.

A versioning tool (AUVESY VersionDog) will guarantee the versioning of SCSS software and ensure the job comparison before and after the roll-back.



The rollback version for the SCCS is the V41 backup of 12/11/2023.

Since the SCSS implementation of the roll-back point has already been validated in the past, the revalidation won't need to be repeated.

6. REFERENCES

[1] C.Boucly, C.Durmus, N.Magnin, Presentation to explain the motivation to deploy LBDS remote simulator during YETS#23-24., EDMS-2997696-1 (CERN, Geneva, 2023).