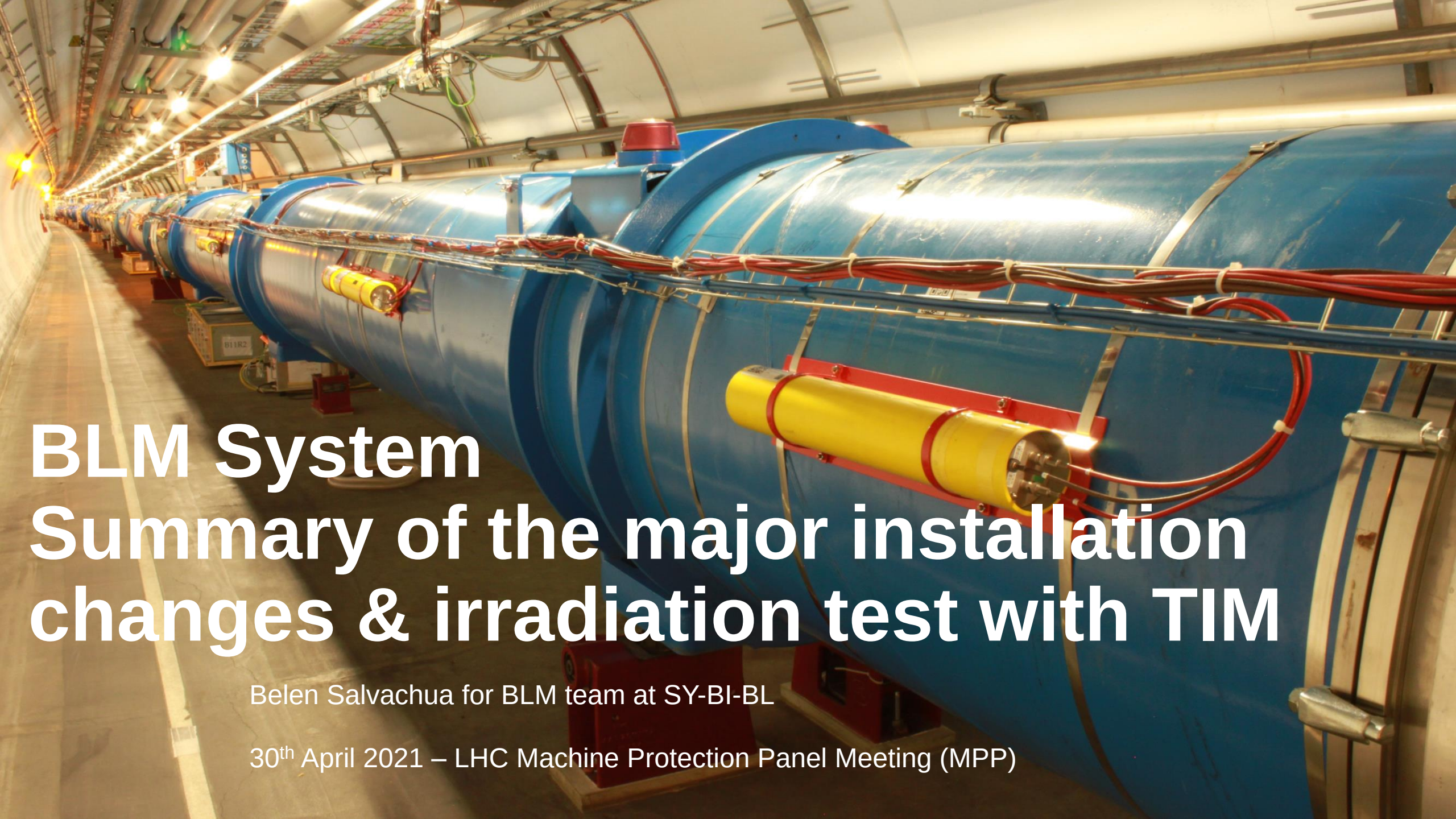


BLM System
Summary of the major installation changes & irradiation test with TIM

Belen Salvachua for BLM team at SY-BI-BL

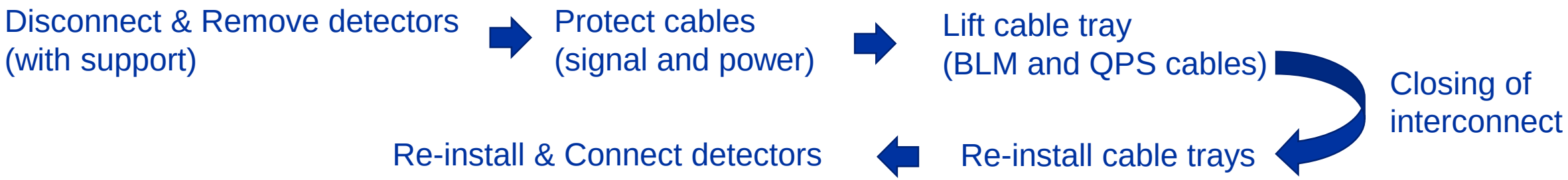
30th April 2021 – LHC Machine Protection Panel Meeting (MPP)

Overview

- BLM removal and re-installation due to LHC DISMAC activities
- BLM layout changes during LS2
- HW commissioning
- Radiation source with TIM wagon
- Summary

BLM changes due to DISMAC: Introduction

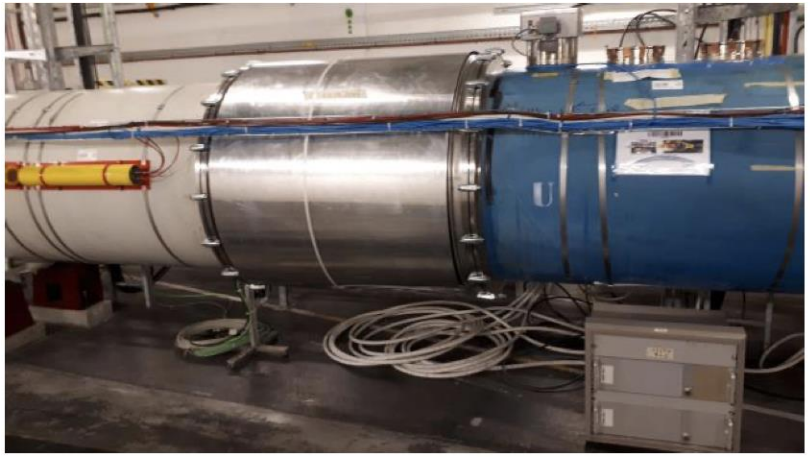
- The activities for the **consolidation of the dipole diode** insulation required the **opening of the dipole interconnects**.
- In order to allow for this the **BLM detectors** mounted on top and left-side of the interconnect **had to be removed** as well the cable trays from BLM and QPS cables lifted.
- DISMAC progress including BLM: https://indico.cern.ch/event/667601/
- Detailed BLM activities for DISMAC discussed at the Readiness Review - 27th Nov. 2018, DISMAC Readiness Review - LHC BLM System

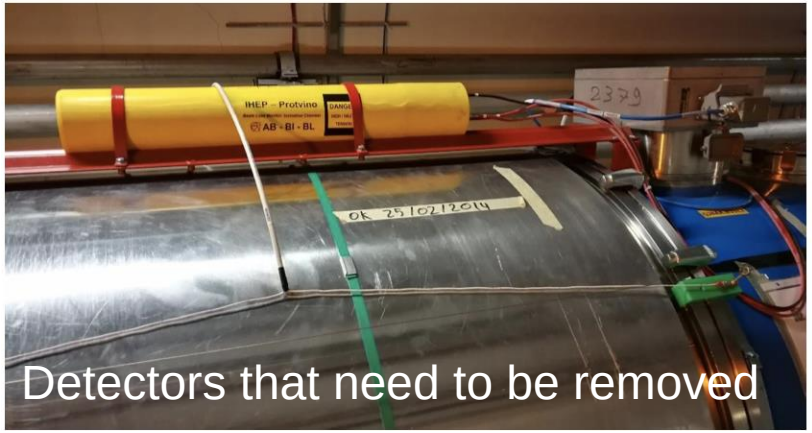


After DISMAC a full commissioning of all BLM detectors is needed

BLM changes due to DISMAC: Activity

DISMAC activities in Cells 8 – 34 for all sectors and special interventions due to magnet exchange activities (SIT)





BLM changes due to DISMAC: Status and Progress

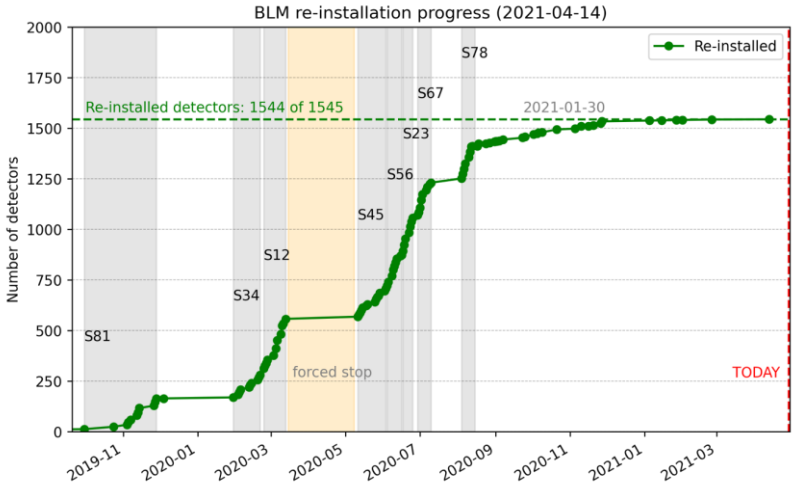
- Re-installation started 30th Sep 2019.
- Installation rate depending on availability.

Total BLM detectors (IC, LIC and SEM)	Removed channels	Disconnected
3986	1421	2097
100%	35.6%	52.6%

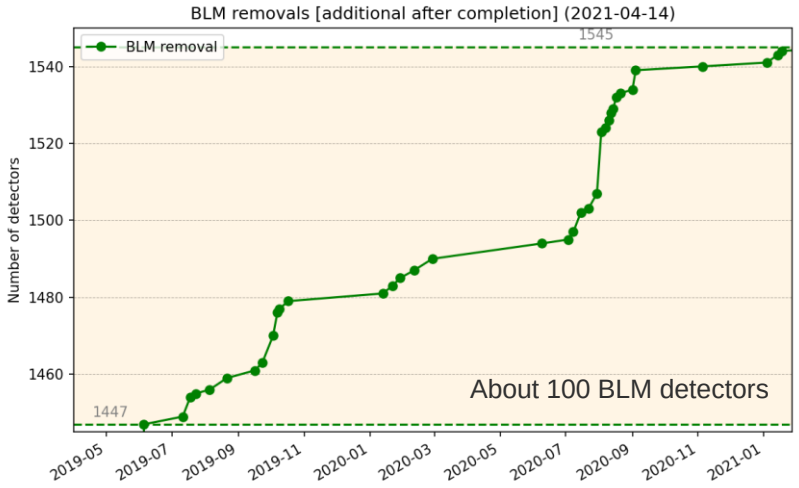
- From March 2019 plan changed to install BLM in all close interconnects – no waiting for the vacuum checks.
- Risk taken to remove detectors again in those locations where vacuum leaks where found.

99.9% detectors installed

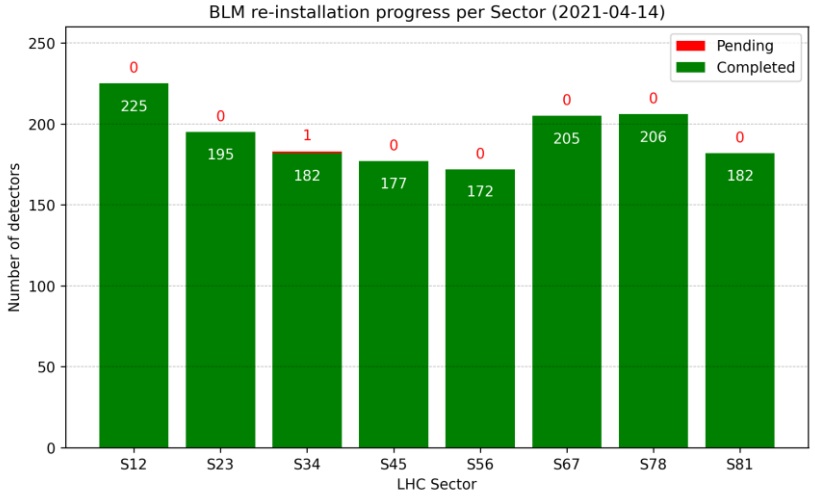
Only **1 detector missing in QEBI.11L4** where re-alignment and tomography should be done in June/July after powering tests



Re-installation progress



Additional removals after completion



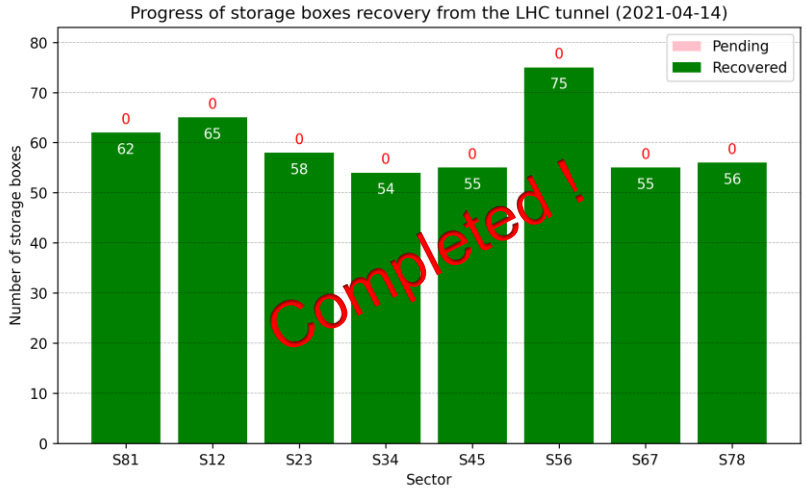
Re-installation progress per Sector

BLM tunnel material and QR code labels

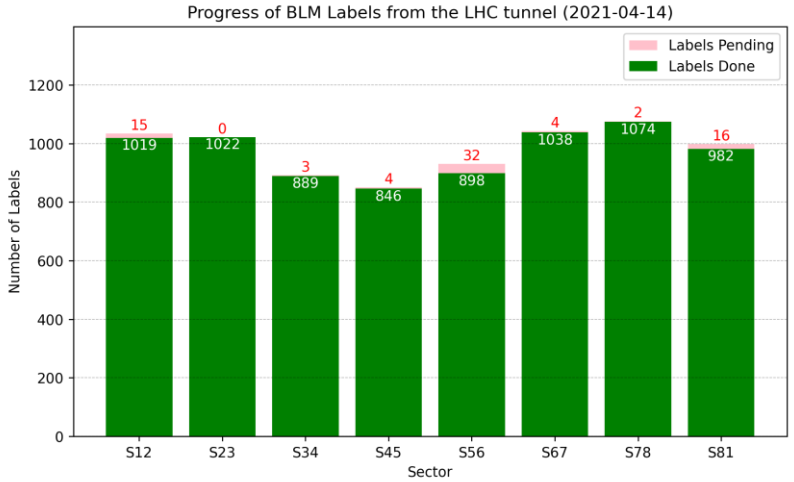
Recovery of storage material from tunnel and distribution of new barcode labels

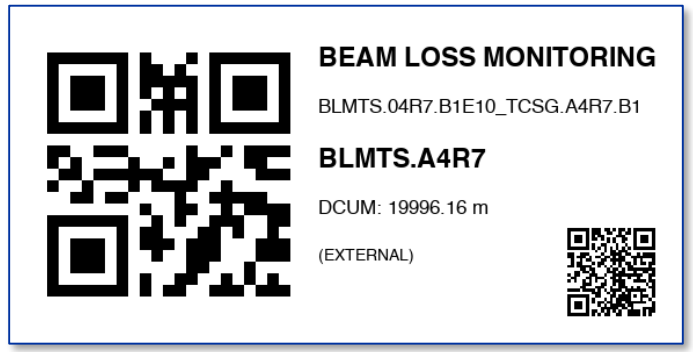
- 460 Storage Boxes distributed in the ring collected: activity completed Sep 2020
- 7844 Barcode Labels distributed in the ring. Labels need to be re-printed for the remaining cases when Layout database will be updated. Activity paused.

Storage Boxes Collection



Distribution of BLM QR codes



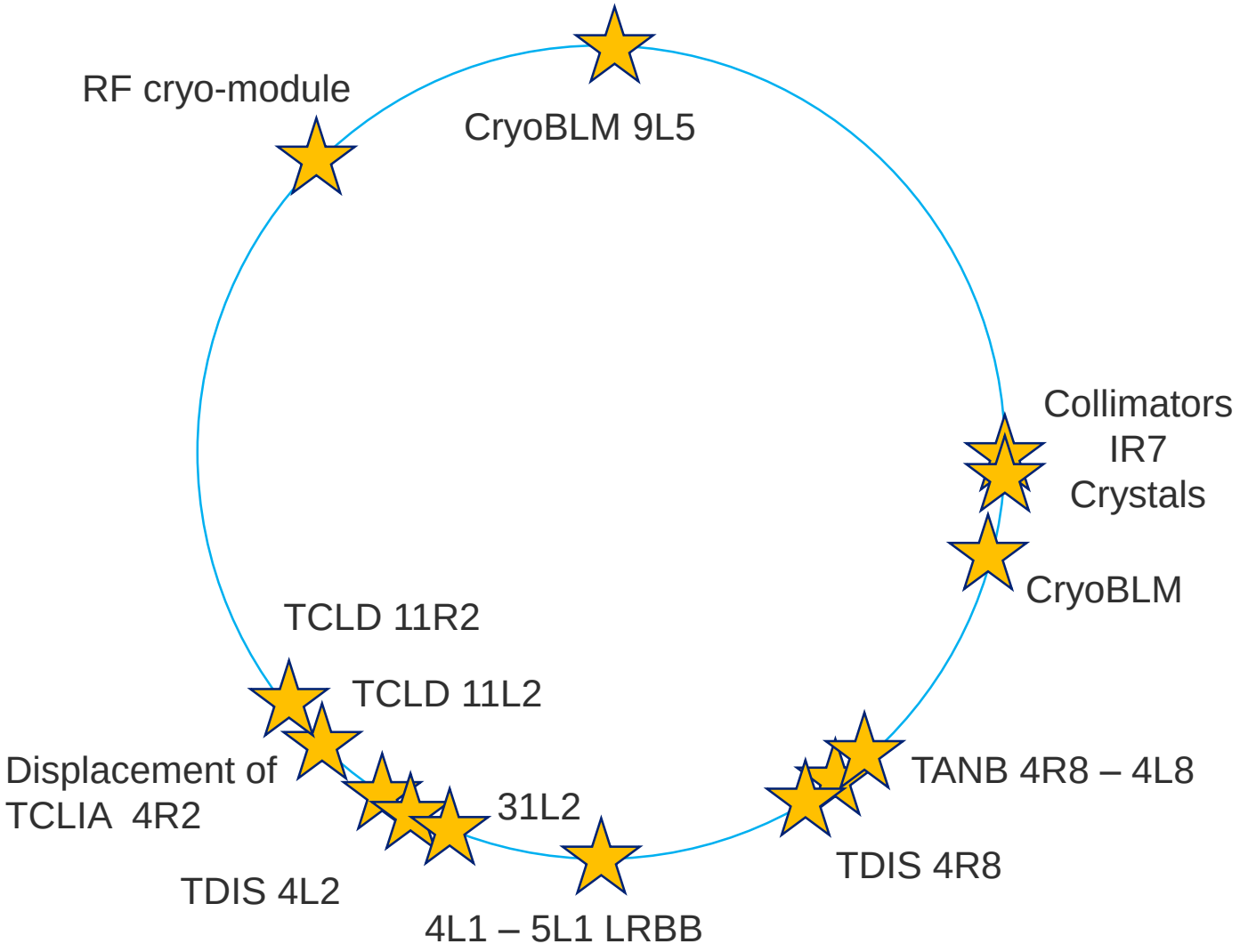


New BLM labels distributed in order to facilitate the autonomous identification of the BLM detectors with the TIM robot

BLM layout changes during LS2

Additional installation cases distributed along the machine:

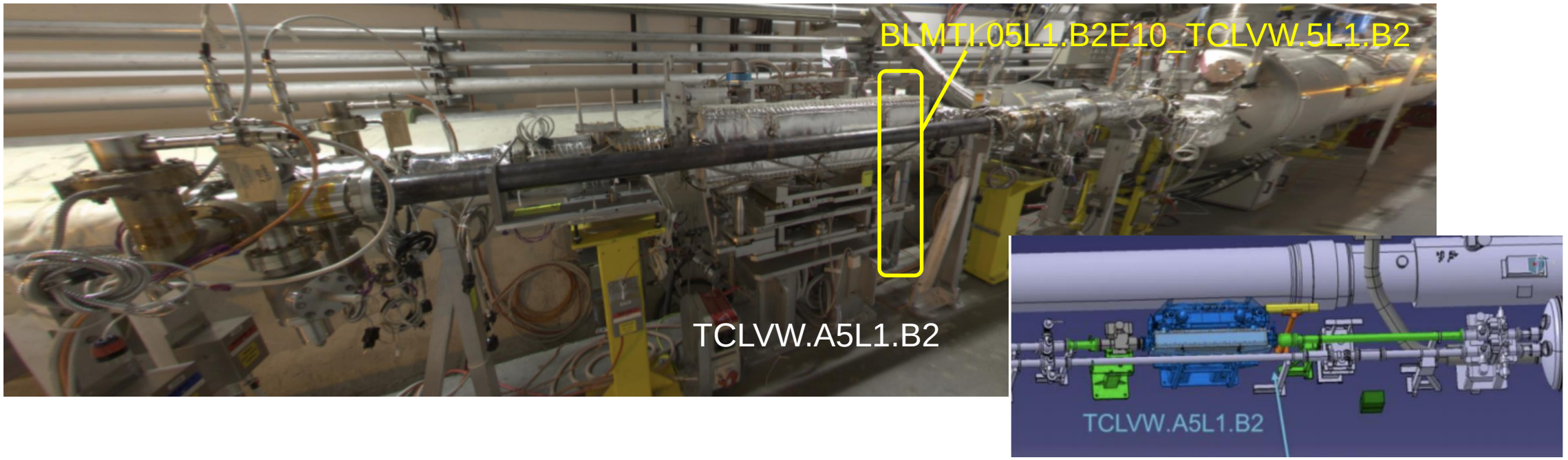
- Following different subsystem changes
- Upgrade of the BLM system



IP1 - Changes due to LRBB wire collimator

Moving the Long Range Beam Beam wire collimator from Beam 2 to Beam 1

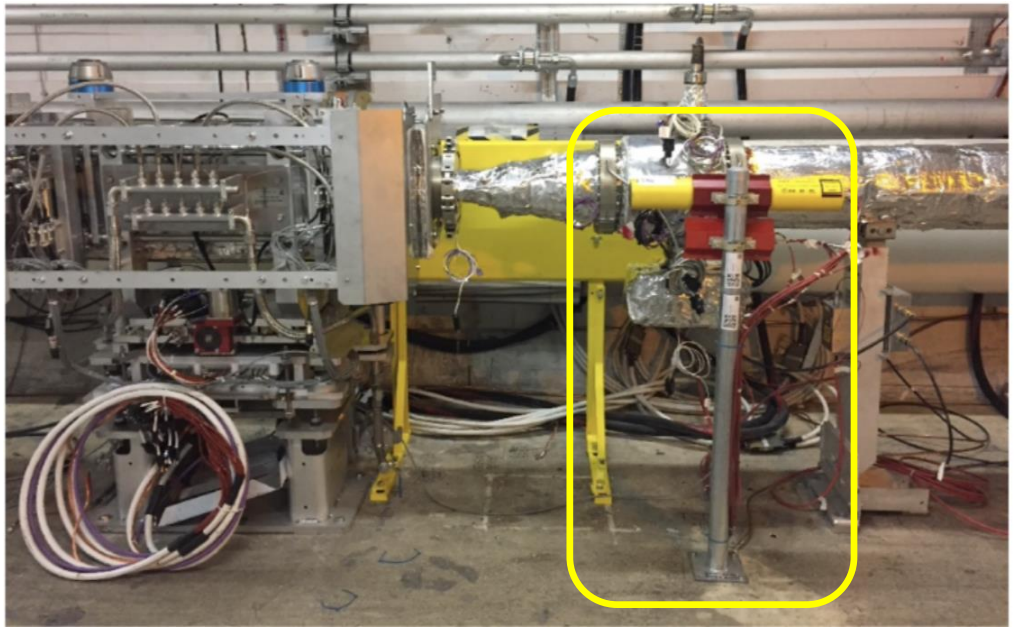
- Removal of the TCLVW.A5L1.B2 collimator, replaced by a vacuum pipe.
- Internal BLM detector can be also removed.
- The collimator will replace the TCTPV.4L1.B1 – no additional BLM needs to be installed
- LHC-TC-EC-0019



IP2 - Changes due to TCLIA displacement

Displacement of TCLIA.4R2 by 2.2 m towards IP2.

- BLM IC and LIC detectors follow the displacement to preserve the relative position.



PRE-LS2			POST-LS2		
Official Name	**Expert Name**	**DCUM**	**Official Name**	**Expert Name**	**DCUM**
BLMTI.A4R2	BLMTI.04R2.B1I10_TCLIA.4R2	3407.70	n/c	n/c	3405.49
BLMTL.A4R2	BLMTL.04R2.B1I10_TCLIA.4R2	3407.70	n/c	n/c	3405.49

IP2/IP8 - Changes due to TDIS upgrade 4L2 – 4R8

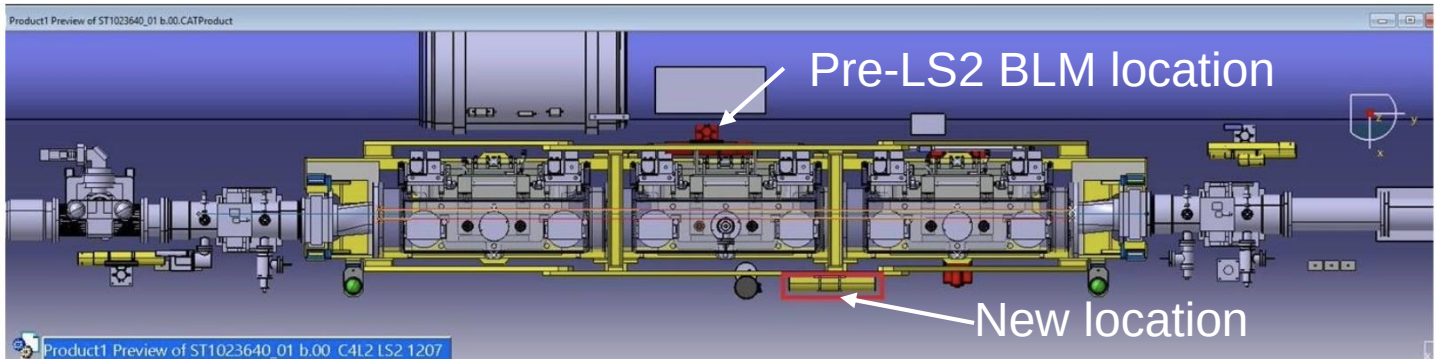
Replacement of the TDI by the TDIS
Upgrade of TDI in order to cope with LIU and HL-LHC beam requirements (LHC-TDIS-EC-0001)

- IC and LIC detectors moved to the internal side due to space constrains
- Installed directly on the TDIS support with a special support.
- BLM names changed to follow the change of hardware.

i.e. BLMTI.04L2.B1E10_TDI.4L2.B1

↓

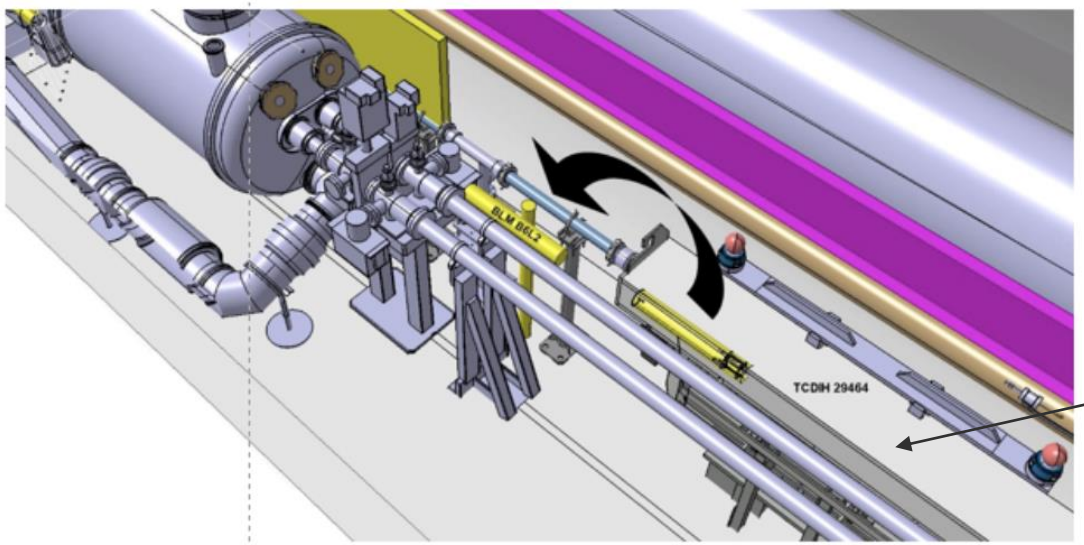
BLMTI.04L2.B1I10_TDIS.4L2.B1



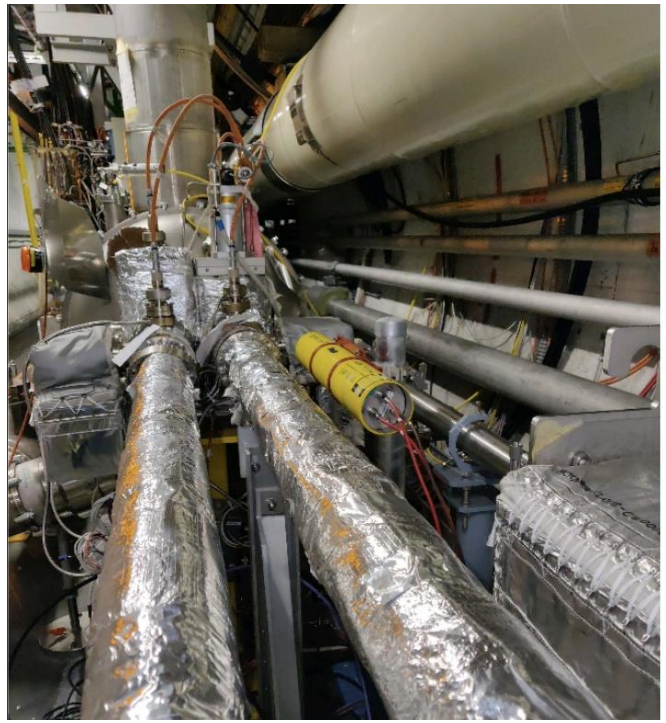
IP2 – Changes due to TCDIH displacement

Displacement of the TCDIH.29464 by 1 m

- Transfer line collimator TI2, affecting BLM (IC and LIC) detectors in cell 6L2.
- BLMQI.06L2.B1E30_MQML displaced by 1 m, following the change.



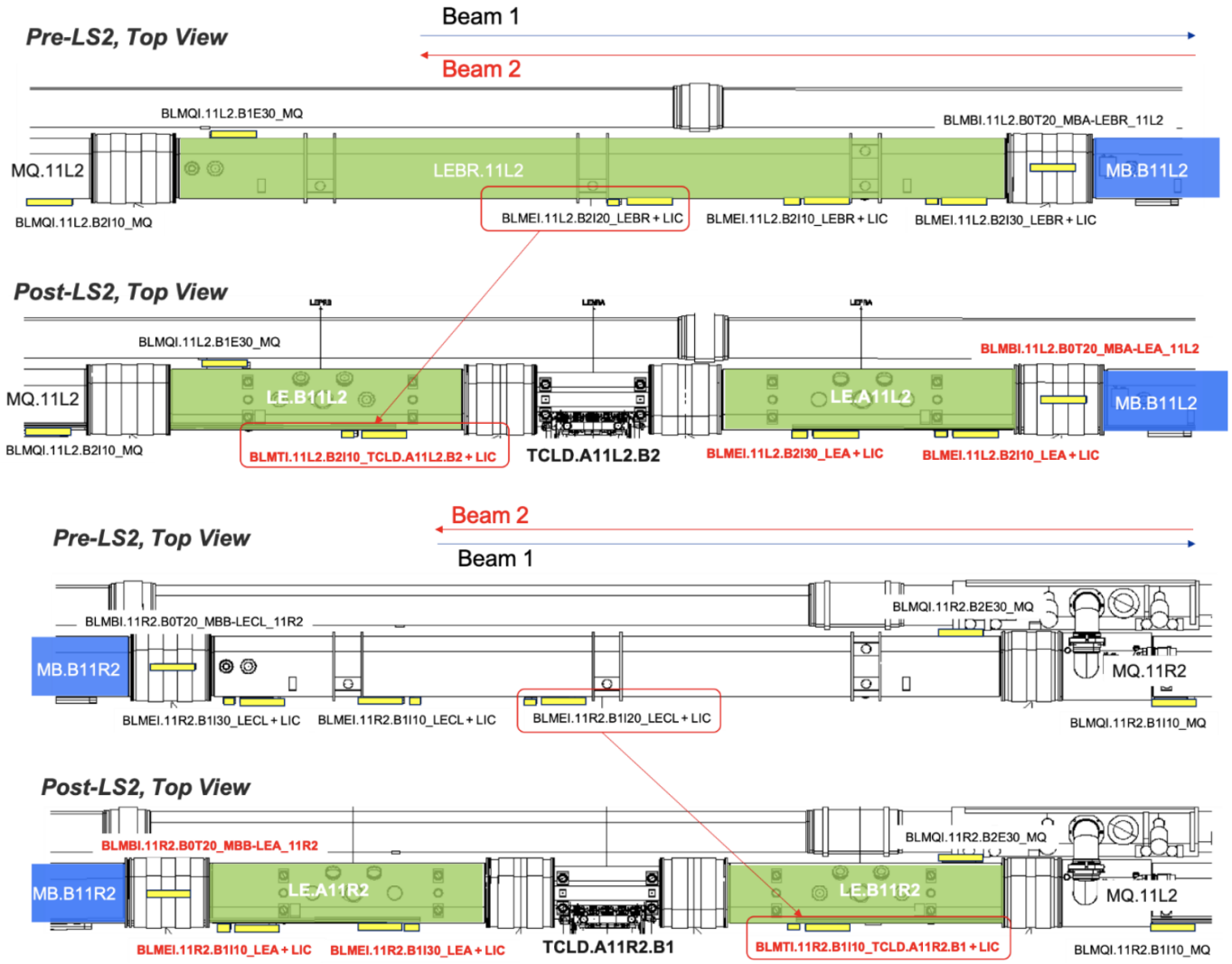
TCDIH.29464



IP2- Changes due to installation of TCLD

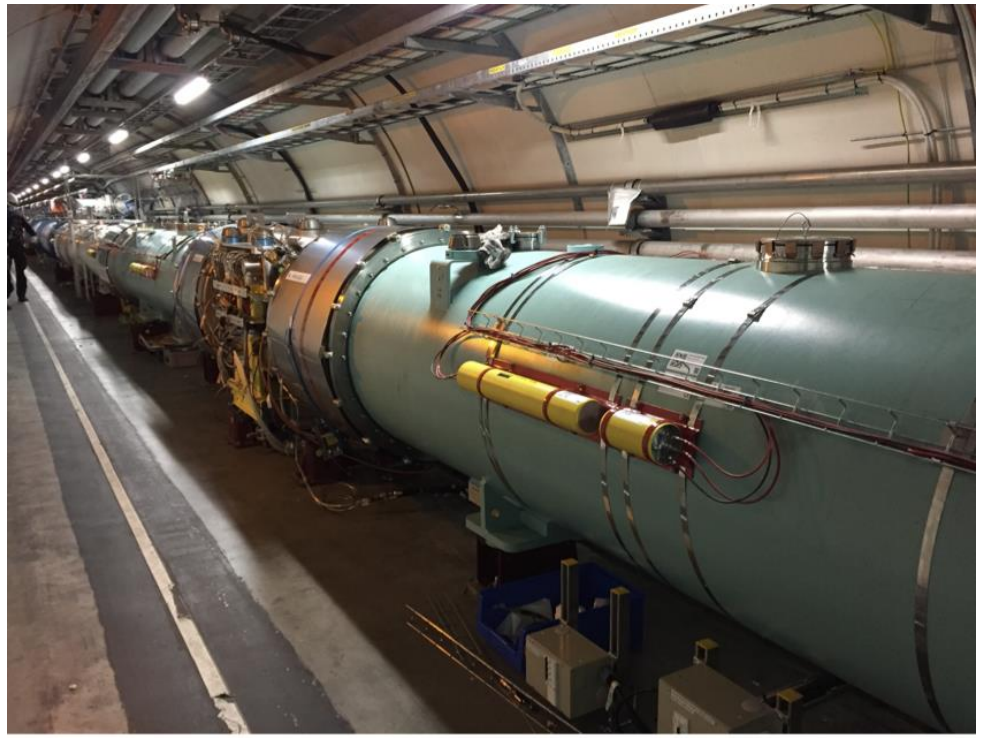
Installation of the TCLD collimator at the location of the empty connection cryostats in 11R2 and 11L2.

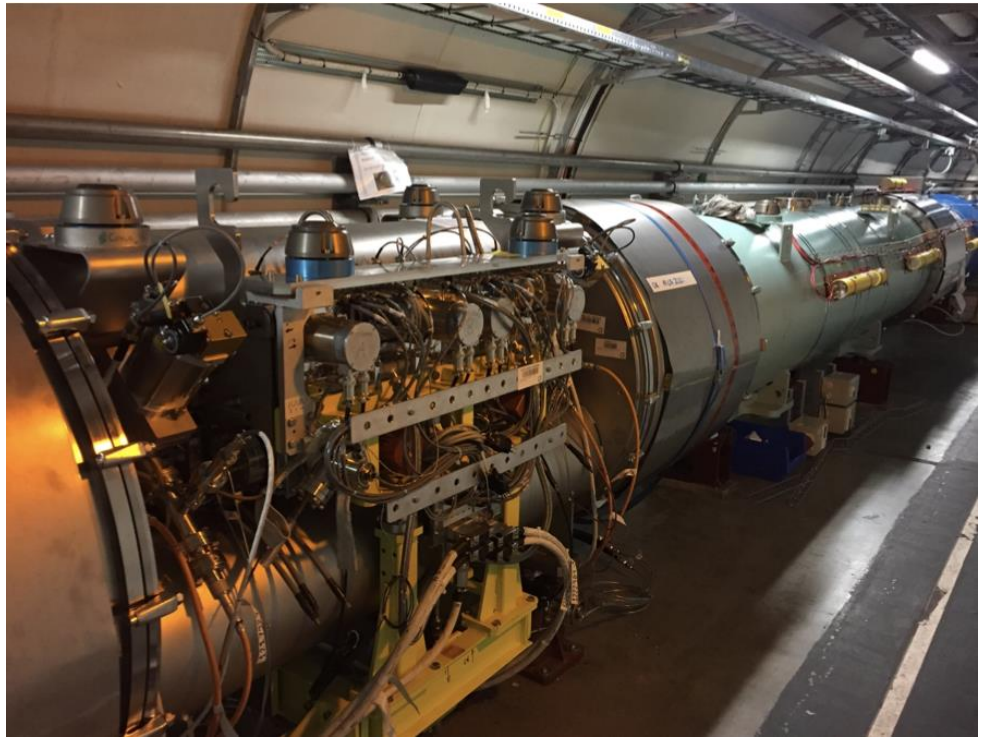
- LHC-TC-EC-0012
- BLM detectors in these locations were removed.
- Signal and power cabling and connections done as new.
- 9 BLM affected per side



IP2- TCLD: installation pictures

Example of the new installation around the TCLD in IP2
Cable trays what were on the internal side was cut and passed by the QRL side





Changes due to installation of TCLD 11L2 – 11R2

BLM detector names for the empty cryostats have changed as well as the new BLM detectors for the TCLDs

PRE-LS2		POST-LS2	
Official name	**Expert name**	**Official name**	**Expert name**
BLMBI.B11R2	BLMBI.11R2.B0T20_MBB-LECL_11R2	n/c	BLMBI.11R2.B0T20_MBB-LEA_11R2
BLMEL.F11R2	BLMEL.11R2.B1I30_LECL	n/c	BLMEL.11R2.B1I10_LEA
BLMEI.F11R2	BLMEI.11R2.B1I30_LECL	n/c	BLMEI.11R2.B1I10_LEA
BLMEI.H11R2	BLMEI.11R2.B1I10_LECL	n/c	BLMEI.11R2.B2I30_LEA
BLMEL.G11R2	BLMEL.11R2.B1I10_LECL	n/c	BLMEL.11R2.B2I30_LEA
BLMEL.H11R2	BLMEL.11R2.B1I20_LECL	BLMTL.H11R2	BLMTL.11R2.B1I10_TCLD.A11R2.B1
BLMEI.I11R2	BLMEI.11R2.B1I20_LECL	BLMTI.I11R2	BLMTI.11R2.B1I10_TCLD.A11R2.B1
BLMQI.B11R2	BLMQI.11R2.B2E30_MQ	n/c	n/c
BLMQI.C11R2	BLMQI.11R2.B1I10_MQ	n/c	n/c

PRE-LS2		POST-LS2	
Official name	**Expert name**	**Official name**	**Expert name**
BLMQI.C11L2	BLMQI.11L2.B2I10_MQ	n/c	n/c
BLMQI.B11L2	BLMQI.11L2.B1E30_MQ	n/c	n/c
BLMEL.G11L2	BLMEL.11L2.B2I20_LEBR	BLMTL.G11L2	BLMTL.11L2.B2I10_TCLD.A11L2.B2
BLMEI.H11L2	BLMEI.11L2.B2I20_LEBR	BLMTI.H11L2	BLMTI.11L2.B2I10_TCLD.A11L2.B2
BLMEL.H11L2	BLMEL.11L2.B2I10_LEBR	n/c	BLMEL.11L2.B2I30_LEA
BLMEI.I11L2	BLMEI.11L2.B2I10_LEBR	n/c	BLMEI.11L2.B2I30_LEA
BLMEL.F11L2	BLMEL.11L2.B2I30_LEBR	n/c	BLMEL.11L2.B2I10_LEA
BLMEI.F11L2	BLMEI.11L2.B2I30_LEBR	n/c	BLMEI.11L2.B2I10_LEA
BLMBI.B11L2	BLMBI.11L2.B0T20_MBA-LEBR_11L2	n/c	BLMBI.11L2.B0T20_MBA-LEA_11L2

IP4 - Changes due to replacement of RF cryo-module

The RF cryo-module ACSGA.5R4.B1 was replaced during LS2.

- One BLM detector was removed, the installation in the exact spot was not possible, it was displaced by 20cm.

PRE-LS2			POST-LS2		
Official Name	**Expert Name**	**DCUM**	**Official Name**	**Expert Name**	**DCUM**
BLMEI.G5R4	BLMEI.05R4.B1I20_ACSGA.5R4.B1	10009.01	n/c	n/c	9989.01

IP7 - Changes due to Collimation

Upgrade of the Collimation system in IP7

- Additional collimators in MoGr jaws with BPM pick-ups and replacement of primary collimators (H/V) with low-impedance collimators.
- BLM detectors were already installed as ‘Extra’ monitors in the reserved collimator slots. Although they had to be removed in some case to facilitate the installation of the collimator.

Location of BLM detectors at the collimators in IP7

Main change is on the database side. The BLM reflects the change on function (protecting an existing element) and the collimator name.

PRE-LS2		POST-LS2	
OFFICIAL NAME	EXPERT NAME	OFFICIAL NAME	EXPERT NAME
BLMES.B6R7	BLMES.06R7.B1E10_TCSM.6R7.B1	BLMTS.L6R7	BLMTS.06R7.B1E10_TCSPM.6R7.B1
BLMEI.B6R7	BLMEI.06R7.B1E10_TCSM.6R7.B1	BLMTI.L6R7	BLMTI.06R7.B1E10_TCSPM.6R7.B1
BLMES.N5R7	BLMES.05R7.B1E10_TCSM.E5R7.B1	BLMTS.N5R7	BLMTS.05R7.B1E10_TCSPM.E5R7.B1
BLMEI.N5R7	BLMEI.05R7.B1E10_TCSM.E5R7.B1	BLMTI.N5R7	BLMTI.05R7.B1E10_TCSPM.E5R7.B1
BLMES.E4R7	BLMES.04R7.B2I10_TCSM.B4R7.B2	BLMTS.F4R7	BLMTS.04R7.B2I10_TCSPM.B4R7.B2
BLMEI.E4R7	BLMEI.04R7.B2I10_TCSM.B4R7.B2	BLMTI.F4R7	BLMTI.04R7.B2I10_TCSPM.B4R7.B2
BLMEI.C4L7	BLMEI.04L7.B1E10_TCSM.B4L7.B1	BLMTI.E4L7	BLMTI.04L7.B1E10_TCSPM.B4L7.B1
BLMES.C4L7	BLMES.04L7.B1E10_TCSM.B4L7.B1	BLMTS.E4L7	BLMTS.04L7.B1E10_TCSPM.B4L7.B1
BLMEI.N5L7	BLMEI.05L7.B2I10_TCSM.E5L7.B2	BLMTI.N5L7	BLMTI.05L7.B2I10_TCSPM.E5L7.B2
BLMES.N5L7	BLMES.05L7.B2I10_TCSM.E5L7.B2	BLMTS.N5L7	BLMTS.05L7.B2I10_TCSPM.E5L7.B2
BLMEI.V6L7	BLMEI.06L7.B2I10_TCSM.6L7.B2	BLMTI.B6L7	BLMTI.06L7.B2I10_TCSPM.6L7.B2
BLMES.V6L7	BLMES.06L7.B2I10_TCSM.6L7.B2	BLMTS.B6L7	BLMTS.06L7.B2I10_TCSPM.6L7.B2
BLMTI.B6L7	BLMTI.06L7.B2I10_TCLA.C6L7.B2	BLMTI.V6L7	n/c
BLMTS.B6L7	BLMTS.06L7.B2I10_TCLA.C6L7.B2	BLMTS.V6L7	n/c

IP7 - Changes due to Crystal Collimation

- **Operational Crystal collimation**
  - After the decision in Nov 2020 not to install the 11T dipole in IR7, the crystal collimation became the first option for ion halo cleaning Run 3. This triggered the review of the beam loss monitoring for these devices, both for diagnostics and for protection.
  - **TCPH 4L7 B1 :** BLM named in DB
  - **TCPH 5R7 B2:** OK, nothing to be done
  - **TCP V 6L7 B1:** new BLM installed
  - **TCP V 6R7 B2:** BLM displaced

EXPERT NAME
BLMTS.04L7.B1E10_TCPCH.A4L7.B1
BLMTI.04L7.B1E10_TCPCH.A4L7.B1
BLMTS.05R7.B2I10_TCPCH.A5R7.B2
BLMTI.05R7.B2I10_TCPCH.A5R7.B2
BLMTI.06L7.B1E10_TCPCV.A6L7.B1
BLMTI.06R7.B2I10_TCPCV.A6R7.B2

Figure 26: Installation picture of the TCPCH.A4L7.B1

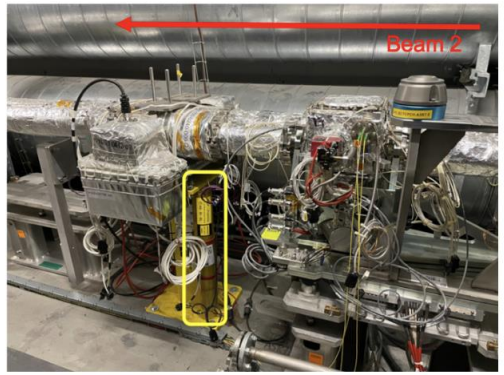


Figure 27: Installation picture of the TCPCH.A5R7.B2

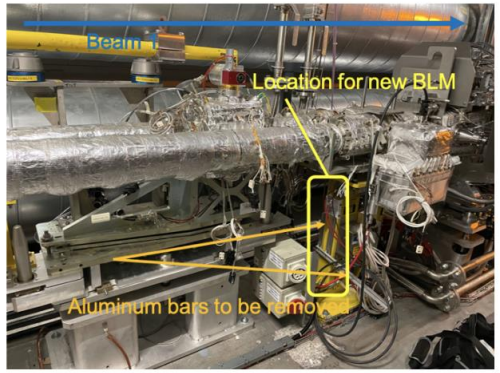


Figure 28: BLM installation proposal for the TCPCV.A6L7.B1

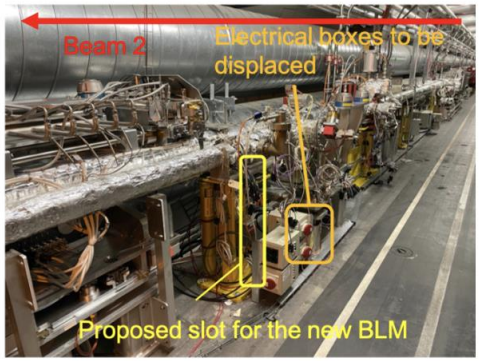


Figure 29: BLM installation proposal for the TCPCV.A6R7.B2

IP8- Changes due to TANB 4R8 – 4L8

New mask (TANB) installed on each side of IR8 (4R8 and 4L8).

- BLM detectors had to be rotated in order to provide enough space for the ion pump access and alignment. A solution could be found by rotating the BLM supports 180 degrees.
- Affecting the BLM of the TCTPV collimators

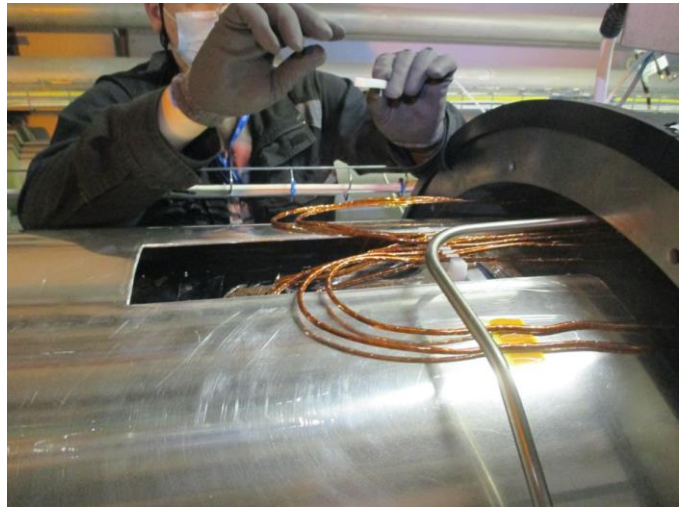
Installation in C4L8

Installation in C4R8

IP5/IP7 - CryoBLM

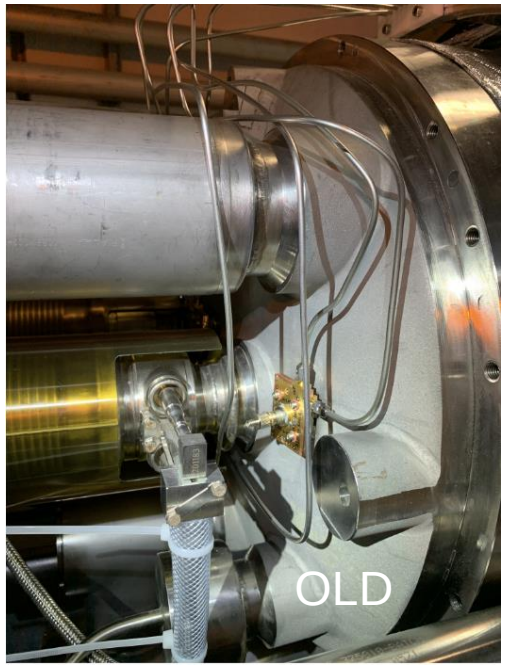
New installation of cryoBLM detectors.

- Removed all old cryoBLM detectors that were a mixture of silicon and diamond.
- Installation of two detectors per side (9L5 and 9R7), all diamond based.
- One internal and one external, one per beam, mounted inside the interconnect.
- Insulation has been added to the cables



Example of names for IP5:

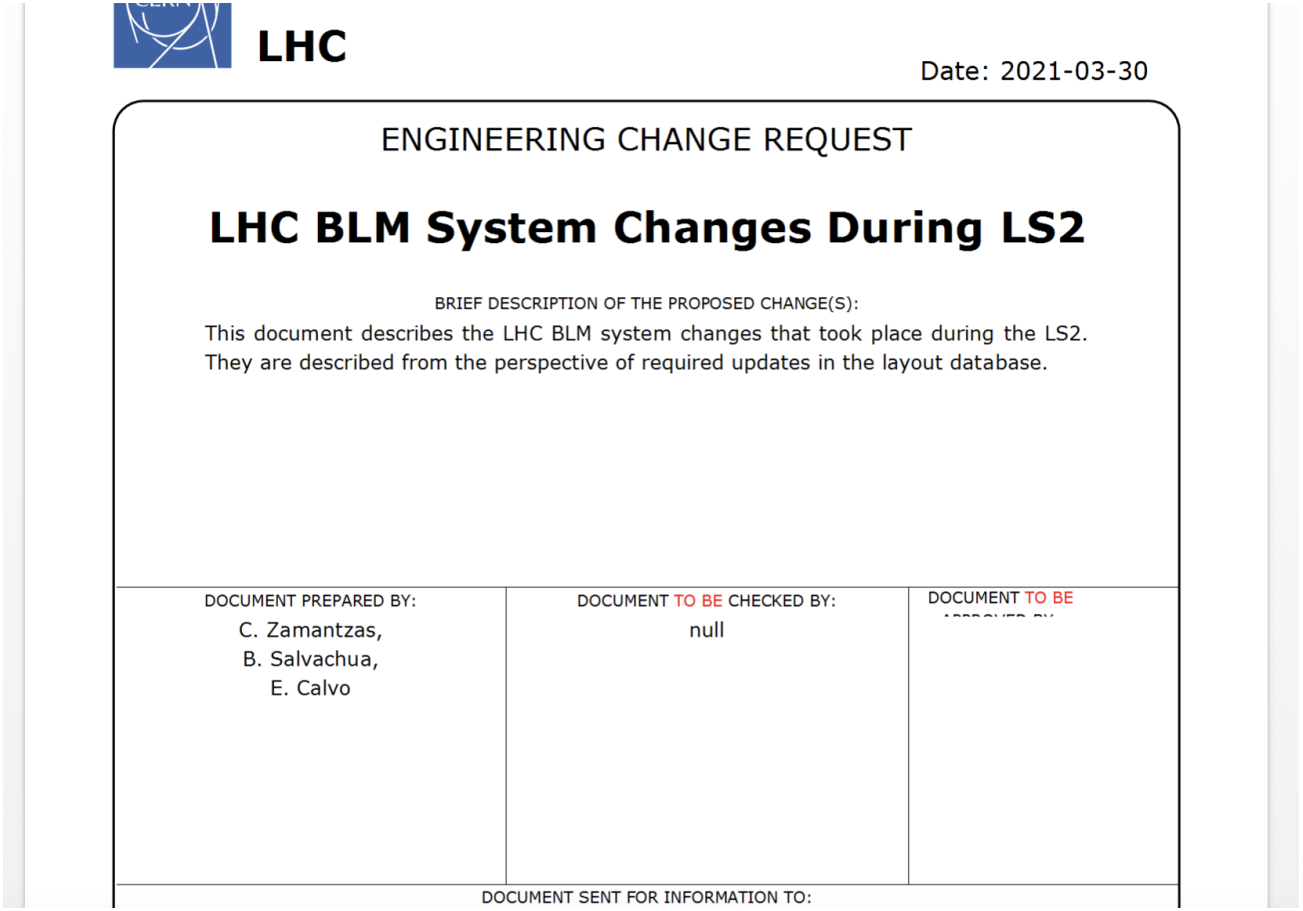
PRE-LS2			POST-LS2		
Official name	**Expert name**	**DCUM**	**Official name**	**Expert name**	**DCUM**
BLMCD.A9L5	BLMCD.09L5.B0T10_MBB	12990.69	n/c	BLMCD.09L5.BxT10_MBB	n/c
New			BLMCD.B9L5	BLMCD.09L5.BxT10_MBB	12990.69
BLMCK.C9L5	BLMCK.09L5.B1I10_MBB	12990.69	Remove from databases		
BLMCK.B9L5	BLMCK.09L5.B2E10_MBB	12990.69	Remove from databases		
BLMCK.A9L5	BLMCK.09L5.B0B10_MBB	12990.69	Remove from databases		



Summary of BLM layout changes during LS2

- BLM changes related to each individual system are mentioned in different system's ECR, that were approved before or during LS2.
- In addition, we are preparing an ECR summarizing all BLM changes:
- Document well advanced and contains all details including new BLM locations and BLM names changes.

Document to be circulating soon



LHC

Date: 2021-03-30

ENGINEERING CHANGE REQUEST

LHC BLM System Changes During LS2

BRIEF DESCRIPTION OF THE PROPOSED CHANGE(S):

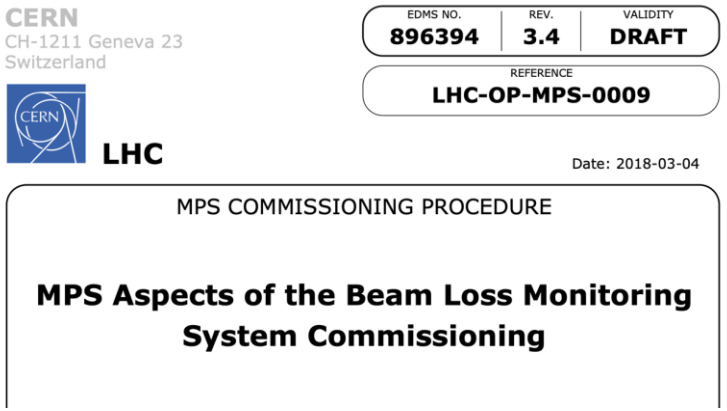
This document describes the LHC BLM system changes that took place during the LS2. They are described from the perspective of required updates in the layout database.

DOCUMENT PREPARED BY:	DOCUMENT TO BE CHECKED BY:	DOCUMENT TO BE
C. Zamantzas, B. Salvachua, E. Calvo	null	

DOCUMENT SENT FOR INFORMATION TO:

BLM system tests (1)

MPS commissioning procedure: LHC-OP-MPS-0009


CERN
CH-1211 Geneva 23
Switzerland

EDMS NO. 896394 | REV. 3.4 | VALIDITY DRAFT

REFERENCE LHC-OP-MPS-0009

LHC

Date: 2018-03-04

MPS COMMISSIONING PROCEDURE

MPS Aspects of the Beam Loss Monitoring System Commissioning

BLM System test performed before each fill/injection period

Description	Test Name
Connectivity of the detectors	Test 710: HV modulation
USER_PERMIT between BLETC and BLECS	Test 331: TC to CS transmission
Parameter comparison HW and DB versions	Test 330: TC & CS vs DB comparison

BLM System test performed continuously

Description	Test Name
Acquisition chain test using 10 pA test signal	Test 712: 10 pA
Communication check of the connectivity with the surface card based on the double optical line	Beam abort if no valid packet arrived from either link
Correct card assignment by reading the embedded serial numbers	Beam abort if different from DB
Integrity check of the on-board memory holding thresholds and settings	Checked by FEC every minute and sent to SIS
Beam energy reception	Test 350: if fails beam energy set to maximum value

BLM system tests (2)

11 hardware tests are defined in the MPS procedure.
The could be very **time consuming** and many require **tunnel access.**

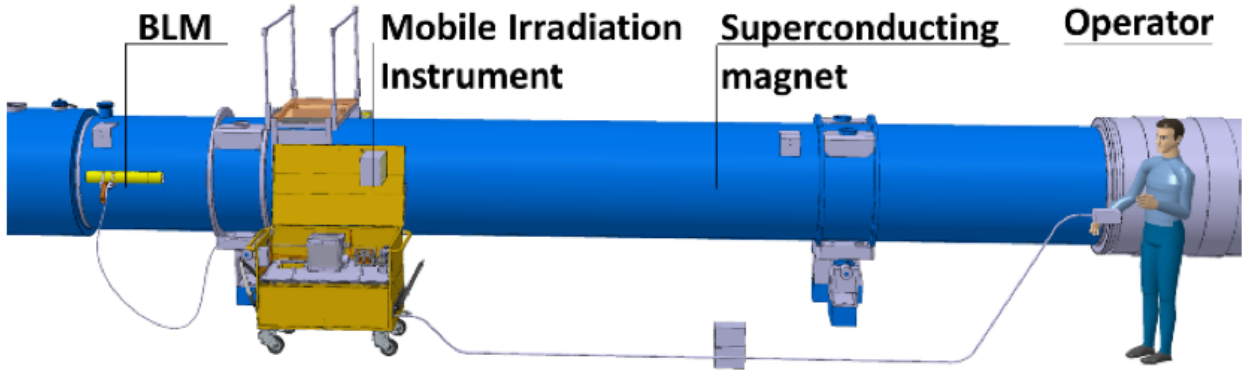
Irradiation with a source: induce a signal in each BLM detector chamber sequentially with a radiation source and check its presence in the corresponding channel; verify its correct assignment to all databases. Check has **to be done on each of the 4000 detectors.**

BLM System test during commissioning

#	BLM Test	Description/Action	Applied to
1	710	HV modulation	All crates
2	712	10 pA test signal, change bias voltage to trigger the failure	One card for each firmware
3		Double optical line comparison	One card for each firmware
4	711	Test 711: 100 pA signal. Increase bias current check RS09 (1.3s)	
5	**720**	**Test 720: Radioactive source test**	**All detectors**
6	730	Test 730: EMC test check 40us and 1.3s RS	All detectors
7	350	Test 350: Beam Energy reception	All BLECS
8	330	Test 330: TC & CS versus DB – comparison performed through the MCS online check	All crates
9		Remove beam permit. For 16 changes, all 12 running sums and 32 energy levels	One card BLETC for each firmware
10	331	Test 331: USER_PERMIT transmission TC to CS	All BLECS
11	332	Test 332: USER_PERMIT transmission from last BLECS card to each rack to CIBU	

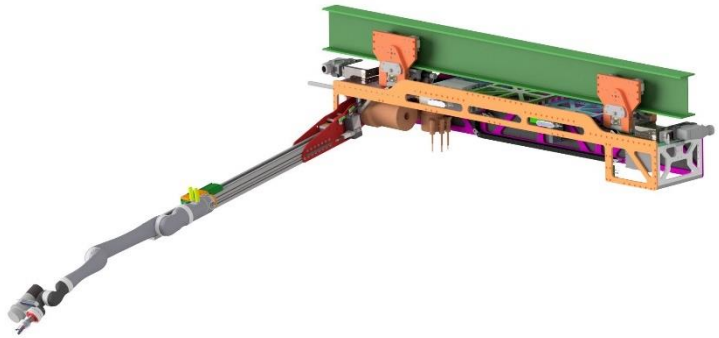
BLM irradiation test

- During LS1 the irradiation test was done manually.
- Activity complex/slow and high radiation to personnel during the activity.
- Since several years there is a collaboration with BE-CEM-MRO (M.Di Castro) to design a new robot on the TIM wagon to perform autonomously this activity.



Dmitry Gudkov (BE-BI)

LHC TIM New Wagon

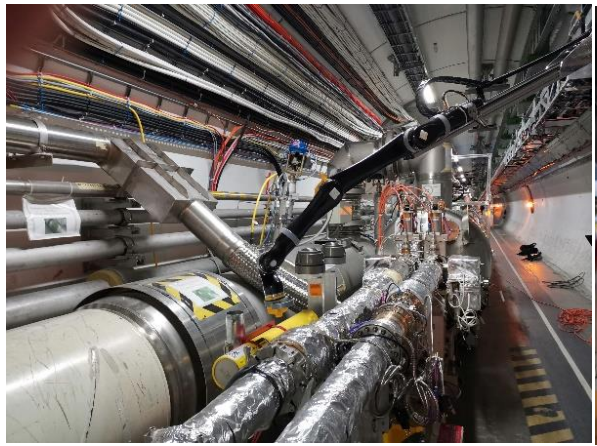


New wagon for the TIM: 9 DOF arm & Sensor suite to identify the BLM & PMIL sensors

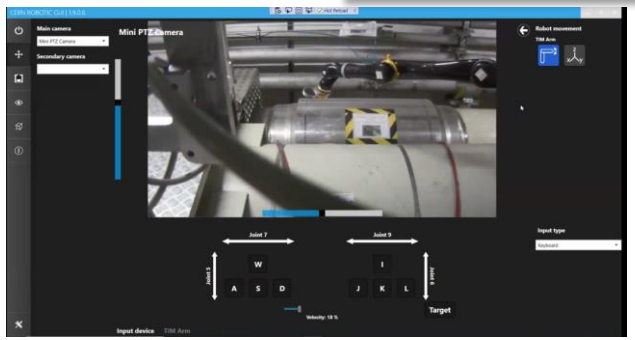
Integrated shielding for the radioactive source

Automatic extraction and safe return of the source to the shielding

Automatic recognition and pose of BLM sensors, working towards autonomous measurements





Irradiation test Planning

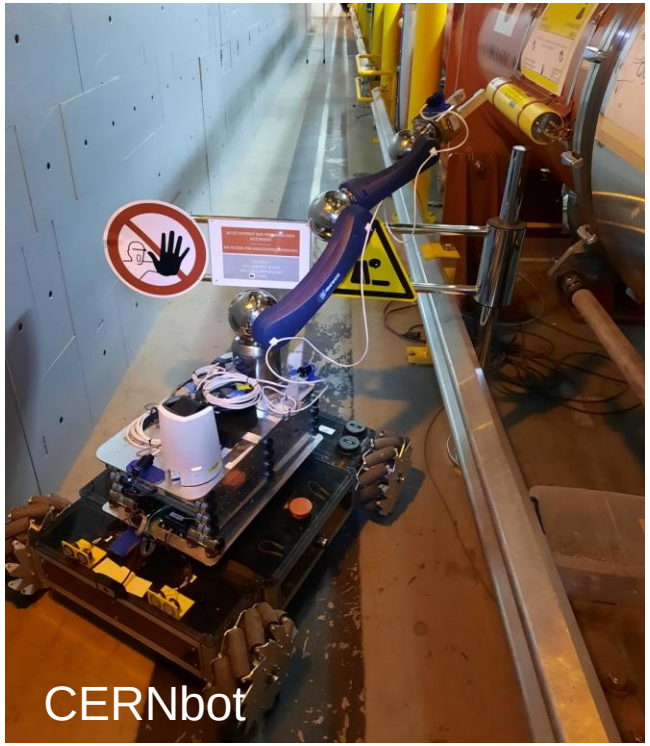
Phase 1
Communication with BLM system

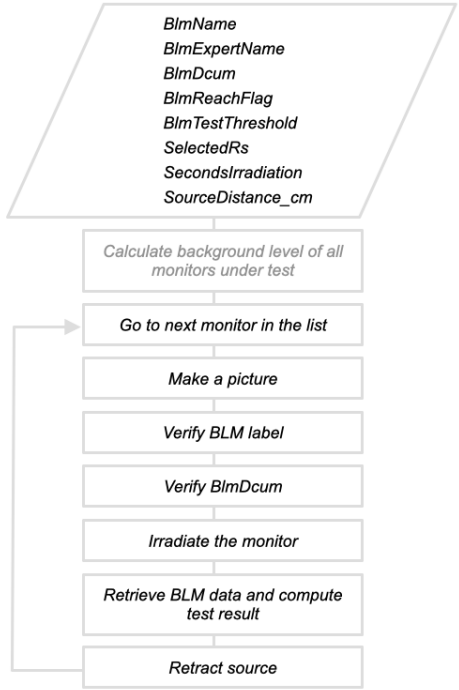
→

Phase 2
Complete procedure – testing of a full sector

→

Phase 3
BLM irradiation test in all the machine

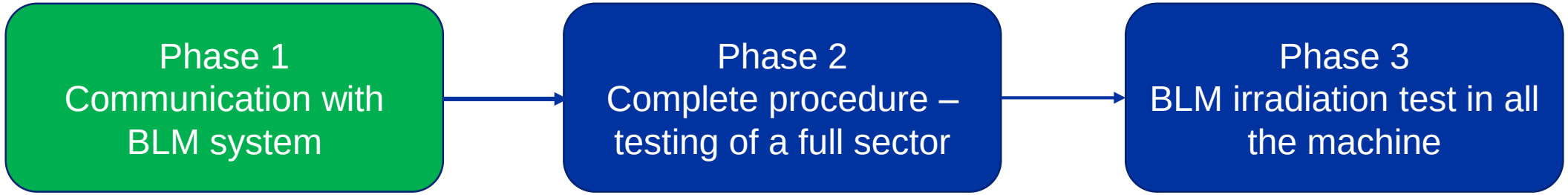




Phase 1:

- Definition of procedure
- Test of communication BLM system – CERNbot
- Tunnel testing with a radiation source
- **Done on 24th Feb 2021**

Irradiation test Planning

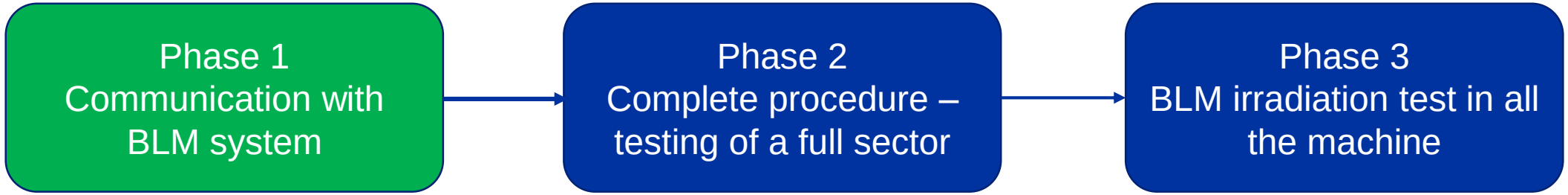


Phase 2:

- Testing of complete procedure – target a full sector S12
- Two radiation sources in parallel – could be 2 TIM wagons or 1 TIM and 1 CERNbot
- 2 operators 6 hours/day from TIM MRO team (mixture of manual and supervisory control, moving towards autonomous operation)
- Estimate 6 BLM detectors/hour: 2 weeks per sector

Maximize the coverage with wagon and CERNbot, however it is known that certain **BLM detectors will not be reachable** and will have to be tested manually. **Estimated 5-10%.**

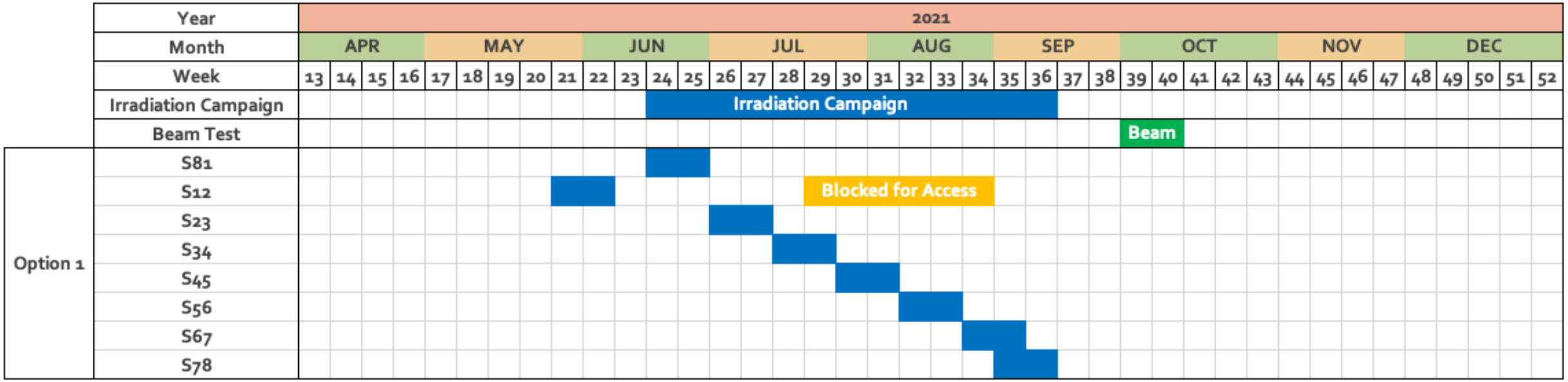
Irradiation test Planning



Phase 3:

- Final irradiation campaign
- Two radiation sources in parallel – could be 2 TIM wagons or 1 TIM and 1 CERNbot
- 2 operators 6 hours/day from TIM MRO team
- **Estimate 2 months for the full machine**
- Activity coordinated with BE-OP

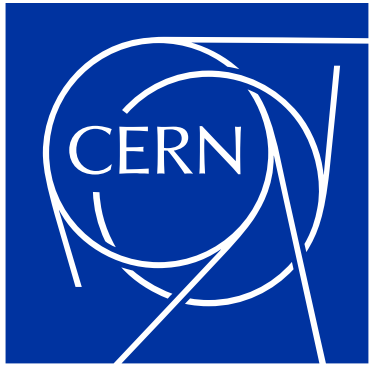
Tentative planning



- Phase 2 in S12 planned for W21-W22 (end-May)
- Phase 3 tentatively starting in W24 – 14th June (stopping on 18th Friday for DSO test)
- Order of LHC sectors still under-discussion, list will come from OP.
- TIM operation in parallel with magnet powering tests

Summary and Conclusions

- **BLM changes during DISMAC activities:**
  - 35.6% of the system removed and more than 50% of detectors disconnected.
  - Re-installation almost completed 99.9%, one detector foreseen for summer.
- **Special and complex changes in many other locations, in particular:**
  - Installation around the TCLD in IP2
  - BLM at Crystal collimators
- **Few other changes not discussed here:**
  - *Cancellation of 11 T in IP7 – full removal of BLM and cabling had to be re-installed as pre-LS2*
  - Removal of BLM in 31L2 and 16L2
  - TI2/TI8 – replacement of TCDI collimators with longer version, relocation of BLM detectors.
  - TI2 – installation of BLM at the bottom of the PMI2 shaft.
- **Hardware tests outlined – focus on Irradiation test using the TIM**
  - First tests successfully done, tentative schedule in preparation with OP



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Special Interventions

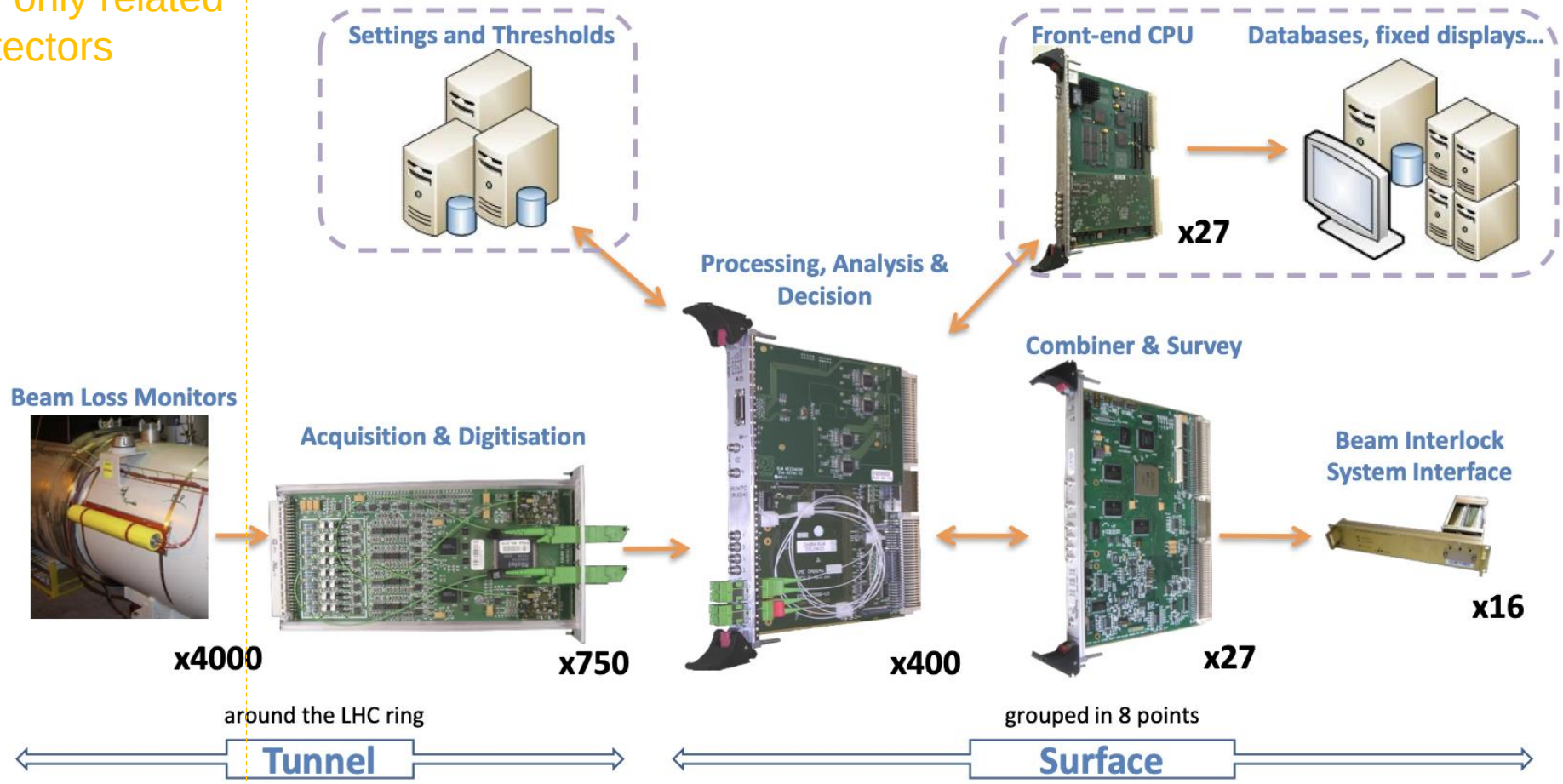
Broken cables/connectors

11L2 - cables trays installed in the back instead of in the magnet sides

LHC Beam Loss Monitoring system

Hardware Changes during LS2 only related to BLM detectors

Firmware and Software changes during LS2



Link to other equipment

MPS commissioning procedure:
LHC-OP-MPS-0009

- **Beam Interlock system**
  - BLM produces interlocked signals.
  - For each point two ‘USER_PERMITS’: one ‘MASKABLE’ and one ‘UNMASKABLE’ BIS input
  - BIS distributes the BEAM_PRESENCE: no test can be launched when there is beam
  - BIS distributes the ENERGY: to adapt the beam abort thresholds
- **Beam Dump system:**
  - Direct interlocked monitors: one on the TCDQ and one on the TCSG
  - Beam abort by comparing the detector signal (voltage) with a reference voltage, only adjusted from the tunnel.