Beam Interlock System
CIBU Connection Review

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Outline:

- CIBU distribution
- Commissioning test acceptance
- Commissioning test results:
  - Linac4
  - Booster
  - SPS Injection
  - SPS ring
  - SPS Extraction beam 1 & beam 2
  - LHC Injection beam 1 & beam 2
  - LHC ring
- Conclusions

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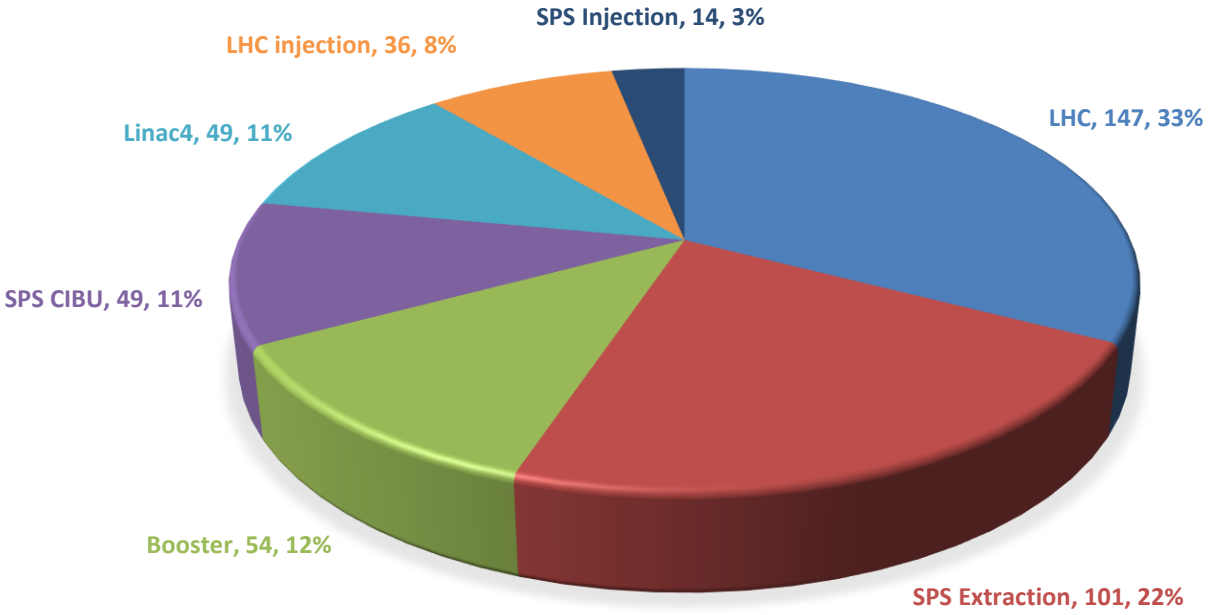
CIBU DISTRIBUTION



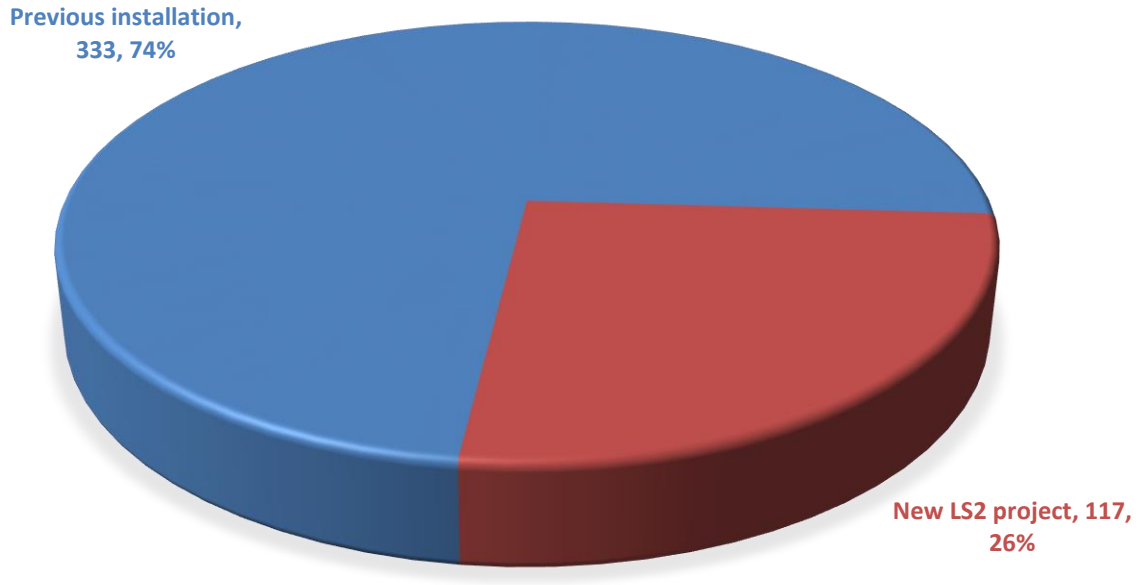
Total CIBU installed : 450

Total CIBU connection* : 498

**Some LHC users require one connection per Beam, in this case a CIBUD type is used (2 x CIBUS electronics in the same enclosure)*

Note : the name CIBU is used to mention a connection with a user. Physically this connection can be realised with a CIBUS, a CIBUD (LHC), or a CIBF (optical version for long distance)

PROPORTION OF NEW CIBU INSTALLED DURING LS2



The new CIBU deployed during LS2:

- Linac4 => 49 CIBU
- Booster => 55 CIBU
- SPS injection => 14 CIBU

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Keep in mind the large variety of user systems: PLC, FPGA, discrete logic, …

To avoid any discrepancies between the different systems/user, at the end of the commissioning, the connection will be reported as "**CONFORM**" or "**NOT CONFORM**"

Report connection between conform and not conform

- Not conform does not mean imminent danger
- If unacceptable, the system will not be connected
- Conform means to fulfil conditions in CIBU user manual and CIBU commissioning doc

CIBU user manual:

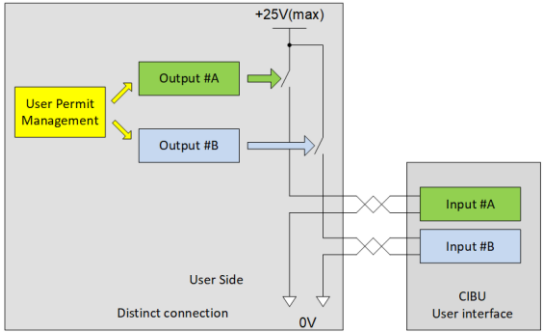
https://edms.cern.ch/document/636589/1.5

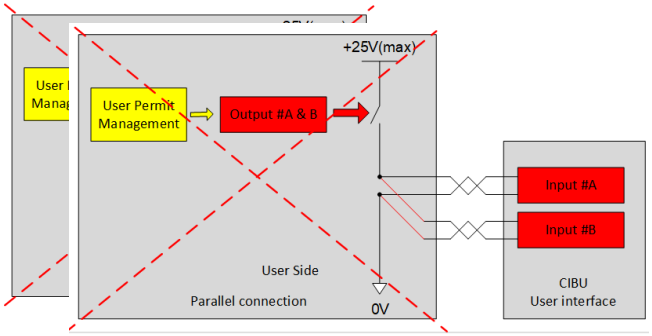
CIBU commissioning document:

https://edms.cern.ch/document/1400288/1

To be conform, the 4 following points must be respected:

1) The User System connection to the CIBU **must be redundant**

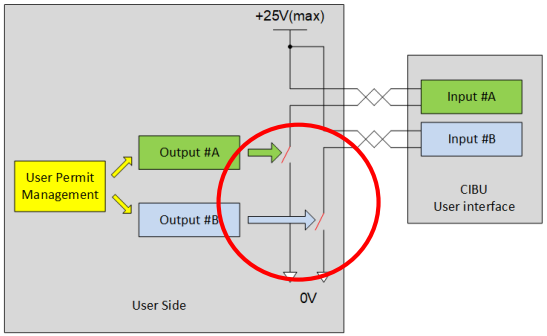




Pictures extract from CIBU commissioning document

If the User cannot "manipulate" in test mode A and B independently, the User has to provide the schematic of its electronics for a verification

Note : User switches positioned on GND are now considered as "CONFORM" if all the other points are respected



OK if:
- Distinct connection
- Ground connected

2) The User system **must provide adequate voltage** level for User Permit A and User Permit

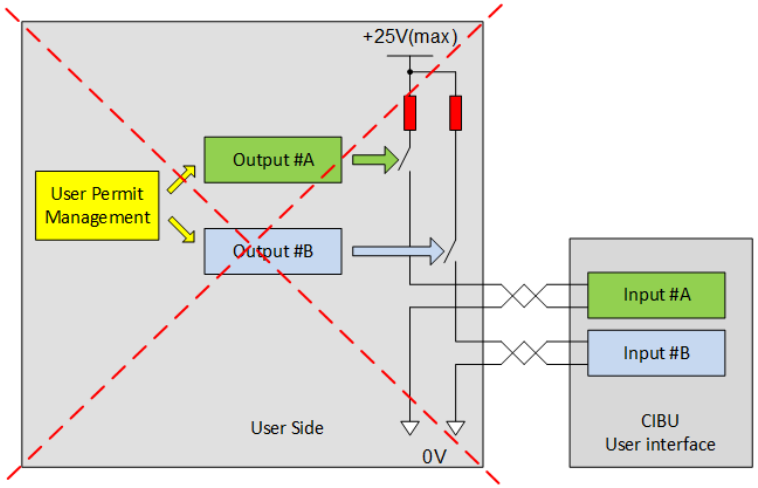
Input Voltage *(V)*	USER_PERMIT *(Boolean)*
< 0.7	FALSE (user **DOES NOT** give permission for beam)
≥ 3	TRUE (user gives permission for beam)

Table extract from CIBU user manual

3) The User System **must provide adequate current** for User Permit A and User Permit

I_{intrue} (min)	Minimum current from USER.PERMIT.+ to .- for USER_PERMIT = TRUE	9 mA
I_{intrue} (max)	Maximum current from USER.PERMIT.+ to .- for USER_PERMIT = TRUE	~15mA
$I_{infalse}$ (max)	Maximum current from USER.PERMIT.+ to .- for USER_PERMIT = FALSE	1mA

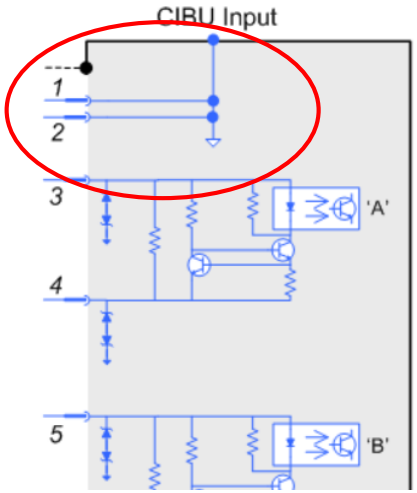
Table extract from CIBU user manual



Picture extract from CIBU commissioning document

4) The pin 1&2 of User Burndy 8 connector relying the User electronic to the CIBU **must be connected to the User Ground**

PIN	Schematic Name	Function
1	GND	EMC improvement by ground proximity
2	GND	EMC improvement by ground proximity
3	User.Permit.A+	Voltage Input + for USER_PERMIT 'A'
4	User.Permit.A-	Voltage Input – for USER_PERMIT 'A'



picture extract from CIBU user manual

Other nonconformities can be reported during the commissioning, but the connection will nevertheless be declared as "CONFORM" (ex: bad shielding on the connection cable, switches on ground side …)

Although it seems very easy to respect the 4 previous points, after the initial getting start of the BIS more than 60% of the connections were not conform …

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To be noted

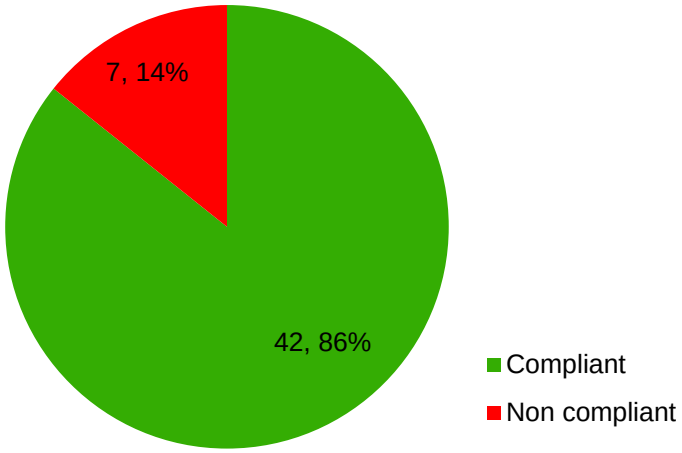
The 500 CIBUs connection are summarized in only seven slides
(no long explanation for each nonconformity)

Some of the nonconformities have been reported during LS1 and no new test have been performed since then *(difficult to remember details)*

The commissioning has been performed by different MI experts
(some of these experts are no longer at CERN, it can be tricky to interpret the tests results)

LINAC4 CIBU CONNECTION STATUS : 100% OF CIBUS TESTED AMONG 49

New LS2 installation

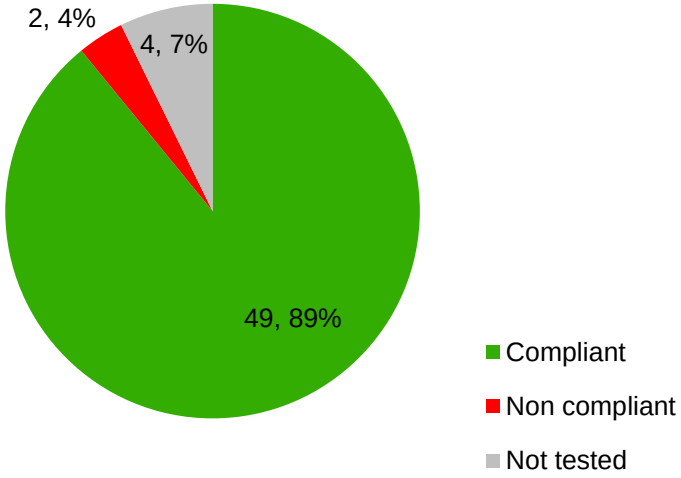


LINAC4 NON-CONFORMITY DETAILS

Systems	Number of CIBU	Parallel connection	No GND
RFQ	1		X
L4RF	1		X
Vacuum	5	X	
Total non-conformities	7		

BOOSTER CIBU CONNECTION STATUS : 4 CIBUs NOT TESTED AMONG 55

New LS2 installation



BOOSTER CIBUs NOT TESTED

- POPS B status (test foreseen on 16/11)
- MPS status
- PSB RF Global
- WIC BTY (installation foreseen 2022)

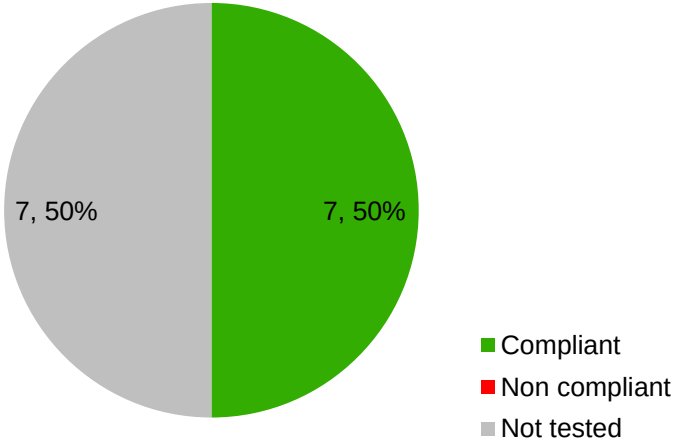
BOOSTER NON-CONFORMITY DETAILS

Systems	Number of CIBU	No GND
AQN BTY.BHZ301 GPS	1	X
AQN BTY.BHZ301 HRS	1	X
Total non-conformities	**2**	

Although most of the user systems connected to the PSB BIC are up to date, these two converters belong to the former generation (no FGC or concentrator inside)

SPS INJECTION CIBU CONNECTION STATUS : 7 CIBUS NOT TESTED AMONG 14

New LS2 installation

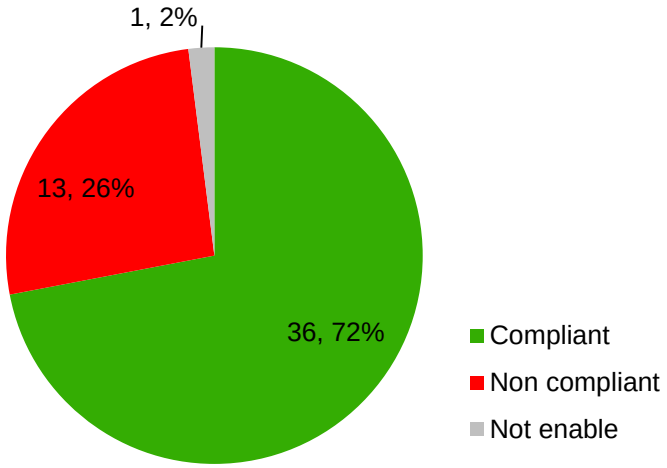


SPS INJECTION CIBU NOT TESTED

- TT2-TT10 Slave BIC
- SPS Injection BIC
- TT10 Circuit Monitoring
- MKP Enable
- MKP State
- SPS Beam Permit
- SBDS TSU

Up to now, 100% of conform connections for the SPS injection BIS

SPS RING CIBU CONNECTION STATUS : 100% OF CIBUS TESTED AMONG 50



SPS RING CIBU NOT ENABLE

(CIBU connected to the BIC with disable jumper in place)

- BLM BDS (tested as conform on 06/2018, waiting for connection approval)

SPS RING CIBU WITH MISSING REPORT

- BCT (new electronic tested in 2017)

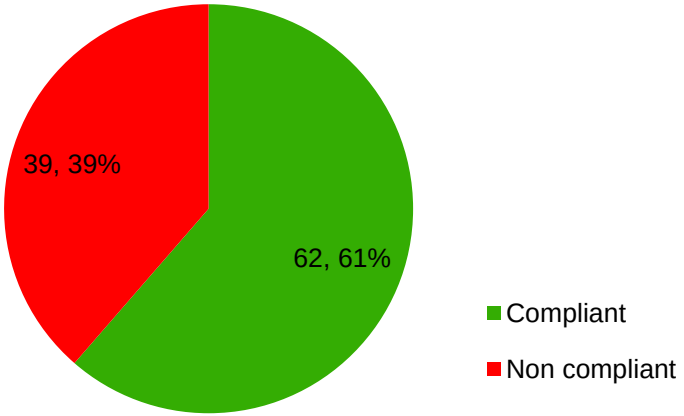
SPS RING NON-CONFORMITY DETAILS

Systems	Number of CIBU	Resistors in series	Serial connection	Switch on GND	No GND
MKD	1		X		X
Q Kicker	1		X		X
MKE4	1		X		X
MKE6	1		X		X
Access Chain 1	1	X			X
FGC Interlock	1			X	X
FGC State Sextupole	1			X	X
Total non-conformities	7				

Systems	Number of CIBU	Resistors in series	Parallel connection	No GND	Remark
BLM	6	X	X	X	Too many errors
Total not tested	6				

The Access Chain electronics will be renovated during LS2, a new commissioning is foreseen before the SPS start-up

SPS EXTRACTION CIBU CONNECTION STATUS : 100% OF CIBUS TESTED AMONG 101



SPS EXTRACTION CIBU WITH MISSING REPORT

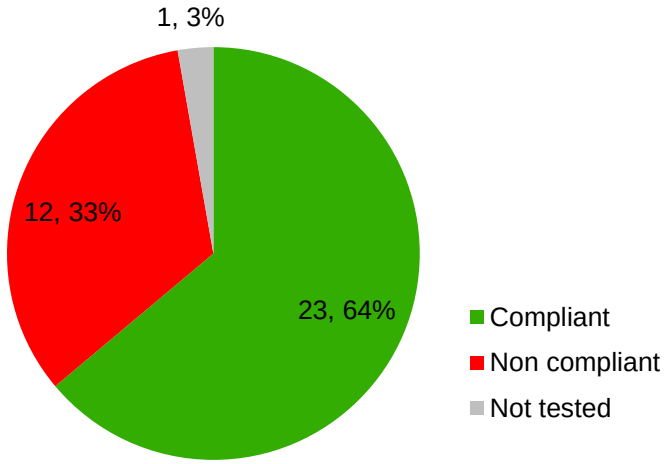
- MKE4 Status
- FMCM_RBI.81607

SPS EXTRACTION 1 NON-CONFORMITY DETAILS

Systems	Number of CIBU	Serial connection	Switch on GND	No GND	Remark
Slave BIC	4			X	BIS local connection
BPF / SBF	4				V false > 1.5V ???
FMCM-MBB	1			X	V true < 3V
FMCM-MBS	1		X	X	V true < 3V
MKE6 status	1	X			
MSE/MST Status	2	X			1.2mA when false
Converter's	18		X	X	
Converter's	1	X	X		
Converter's	2	X	X		Overvoltage
Total non-conformities	34				

Systems	Number of CIBU	Resistors in series	Parallel connection	No GND	Remark
BLM	5	X	X	X	Too many errors
Total not tested	5				

LHC INJECTION CIBU CONNECTION STATUS : 1 CIBU NOT TESTED AMONG 36



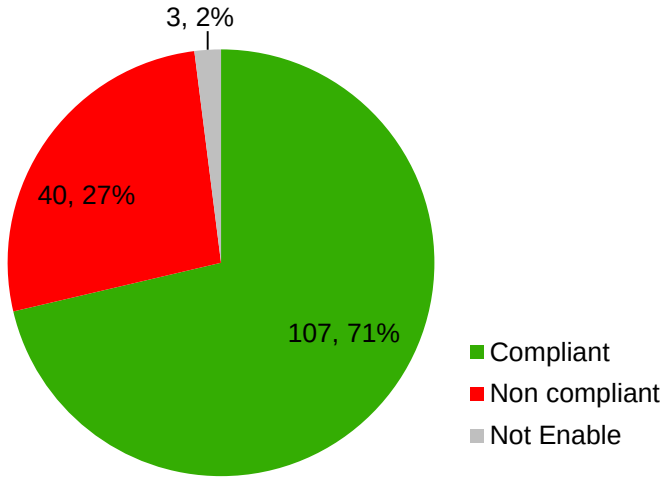
LHC INJECTION NOT TESTED CIBU

- TOTEM (CIBF exchanged on 08/2018)

LHC INJECTION NON-CONFORMITY DETAILS

Systems	Number of CIBU	Resistors in series	Seial connection	Parallel connection	Switch on GND	No GND	Remark
LHC Beam Permit	2					X	No shielding
MSI Convertor Sum Fault (inj1)	1		X		X		
MSI Convertor Sum Fault (inj2)	1	X	X		X		
LBDS	2					X	
CMS	2		?	?		X	Undefined connection
MKI2 / MKI 8	2					X	
MKI2/ MKI8 (BETS/AGK/Erratic)	2		?	?			Undefined connection
Total non-conformities	12						

LHC CIBU CONNECTION STATUS : 100% OF CIBUS TESTED AMONG 150



LHC CIBU NOT ENABLE

(CIBU connected to the BIC with disable jumper in place)

- BCCM A Beam 1 & B2
- BCCM B Beam 1 & B2
- DIDT Test

LHC CIBU WITH MISSING REPORT

- PIC_MSK UA43

LHC NON-CONFORMITY DETAILS

Systems	Number of CIBU	Serial connection	Parallel connection	No GND	Remark
PIC	31	X			Polyfuse in serie
Programable Dump	1			X	
SMP	1				Voltage < 3V
CMS_Operator-switch	1	?	?	X	Connection undefined
CMS_BCM2	1	?	?		Connection undefined
MKI2	1	?	?	?	Secure PLC
MKI8	1	?	?	?	Cable > 30m, Secure PLC
MKQA	1			X	Secure PLC
LBDS (B1 + B2)	2	?	?	?	Secure PLC
Total non-conformities	40				

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Most of the ABT systems are realised with secure PLCs. No tests can be easily performed with these systems

Progressively the CIBUs nonconformities are removed from the accelerators
We have passed from 60% of nonconformities after LS1 to 25% today

When the Users develop new electronics, now we reach more or less 100% conformity

- REMINDER : if a User system is modified (even refurbished…) the interlock team must always be informed in order to take the relevant actions (partial or full recommissioning)

We need to continue our efforts to further improve the percentage of conform systems

Thanks for your attention