

# Improvements of the ALFA and TOTEM Roman Pot Movement System in TS1



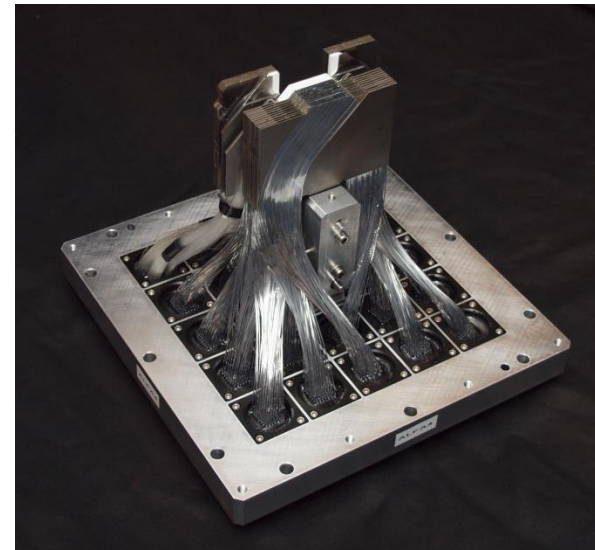
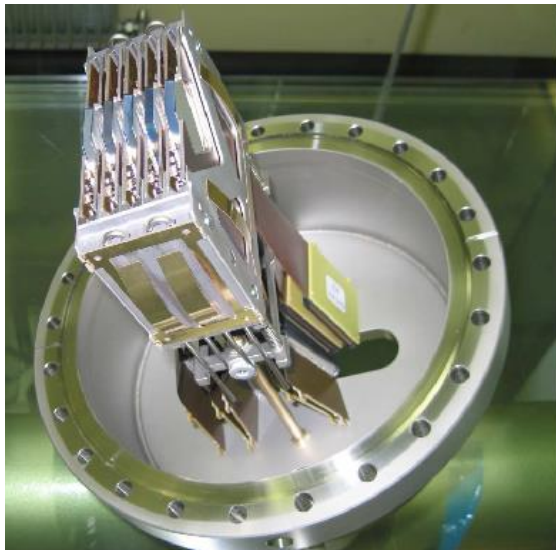
Mario Deile

with input from P. Fassnacht, S. Jakobsen, J. Kaspar, S. Ravat

for the

TOTEM and ALFA Teams

27 April 2012



# The Problem with Very Small Steps



Despite all the tests after the winter activities, one detail was missed:

**Movement steps  $< 30 \mu\text{m}$  not correctly executed**

[although steps  $\geq 30 \mu\text{m}$  perfect within system precision of  $5 \mu\text{m}$ ]

Requested: sequence of  $20 \mu\text{m}$  movements

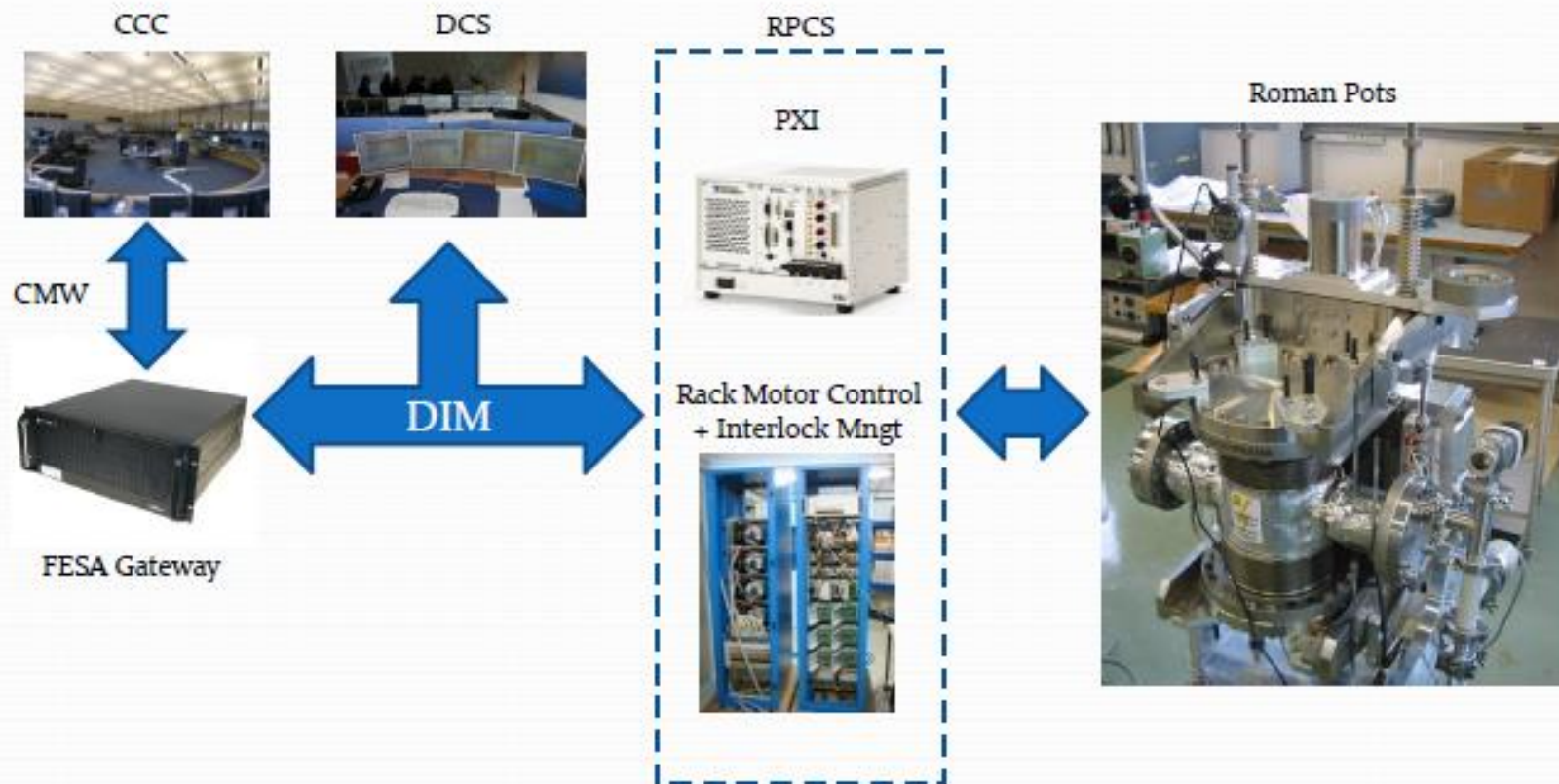
Settings:

$20 \mu\text{m}$



System followed the settings on average,  
but individual steps were wrong.

## RPCS Structure



## RPCS PXI Structure

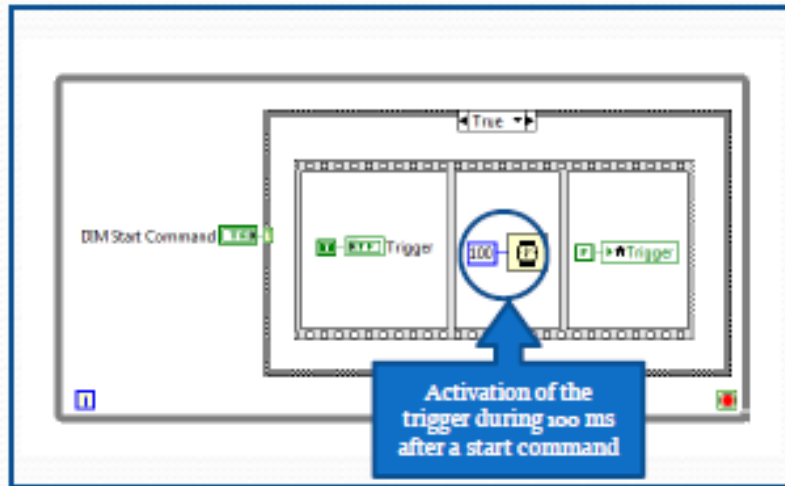


A real time controller to ensure DIM communication between CCC, DCS and RPCS, RS485 communication with motor drives

FPGAs Card to control step motors calculate RP's position

## Step Movements < 6 steps

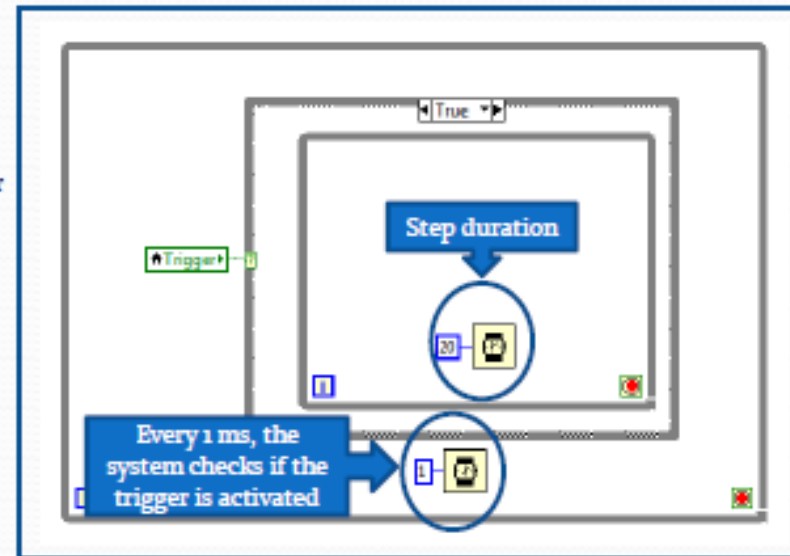
PXI CPU -> DIM command Loop



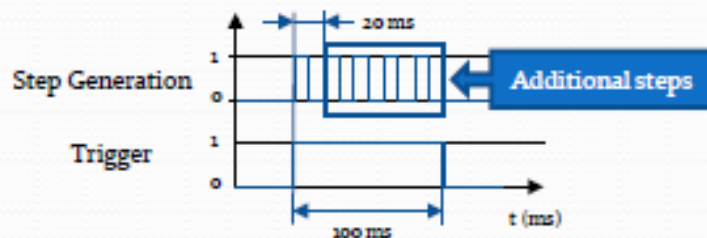
- Step Number
- Direction
- Trigger



FPGA Card -> Step generation loop



One step movement chronogram



=> Reduce the activation time of the trigger to 15 ms



## TOTEM:

See LHC COLL elog: <https://ab-dep-op-elogbook.web.cern.ch/ab-dep-op-elogbook/elogbook/secure/eLogbook.php?shiftId=1043504>

**For all 24 RPs** the following movements were executed (minimum set):

- Big step towards the beam (typically 40 mm to 5 mm): arrival precision  $< 5 \mu\text{m}$
- Series of incremental movements (mostly manual increments, some BBA tests):
  - \* 200  $\mu\text{m}$
  - \* 100  $\mu\text{m}$
  - \* 50  $\mu\text{m}$
  - \* 30  $\mu\text{m}$
  - \* 20  $\mu\text{m}$
  - \* 10  $\mu\text{m}$
- \* some tests with 5  $\mu\text{m}$  = system precision limit  $\approx$  motor step size  $\rightarrow$  rounding effects

**$\rightarrow$  No malfunctions observed**

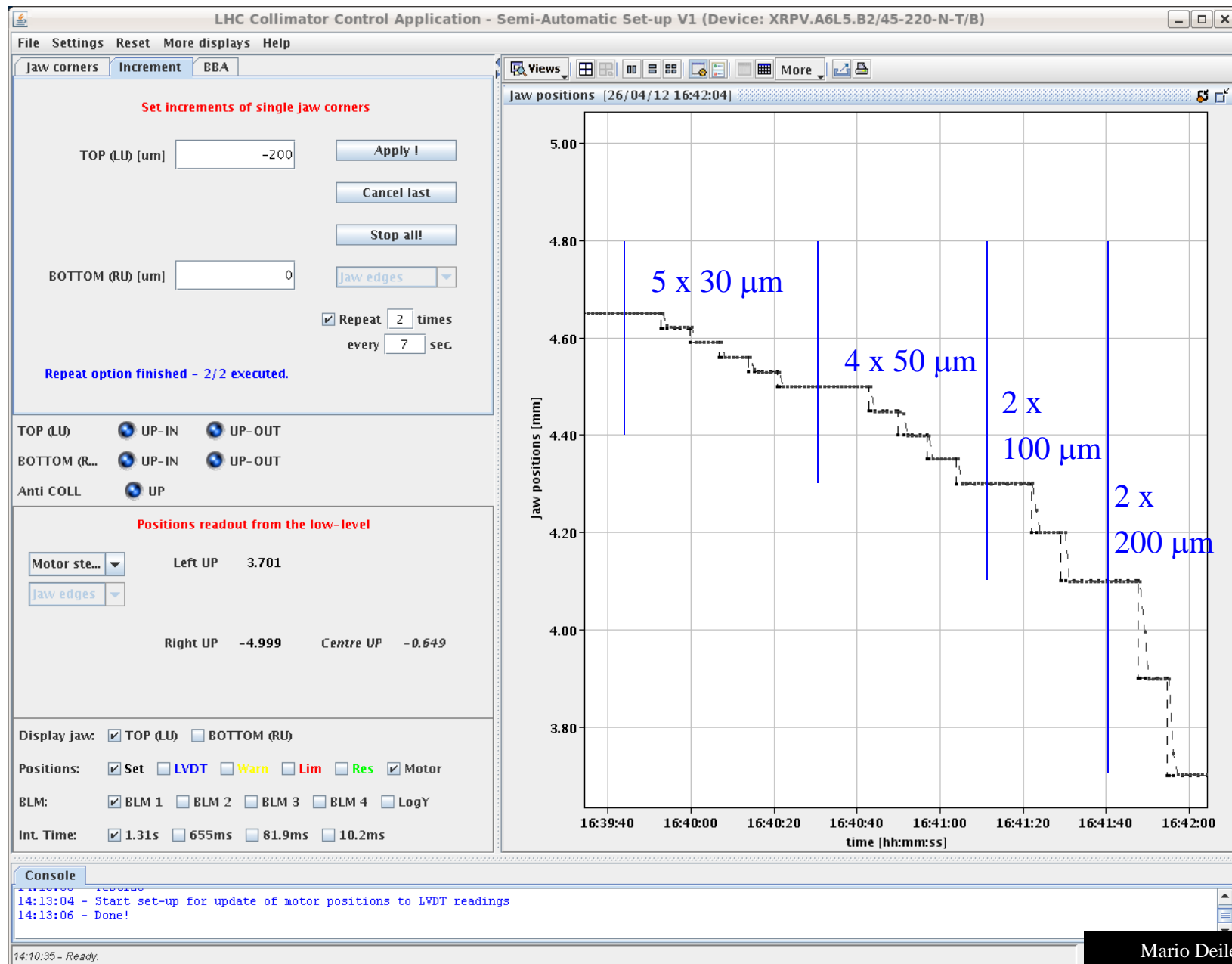
no deviations  $> 5 \mu\text{m}$

At the end: Re-verification of position interlock functionality by dumping on the inner limit for 6 RPs  
(1 Top, 1 Bottom, 1 Horizontal on each beam)

# TOTEM: Test Examples



30  $\mu\text{m}$ ,  
50  $\mu\text{m}$ ,  
100  $\mu\text{m}$ ,  
200  $\mu\text{m}$



# TOTEM: Test Examples



20  $\mu\text{m}$

LHC Collimator Control Application - Semi-Automatic Set-up V1 (Device: XRPV.A6L5.B2/45-220-N-T/B)

File Settings Reset More displays Help

Jaw corners Increment BBA

**Set increments of single jaw corners**

TOP (LU) [um]

BOTTOM (RU) [um]

Repeat  times every  sec.

Repeat option finished - 10/10 executed.

TOP (LU)  UP-IN  UP-OUT  
BOTTOM (R...  UP-IN  UP-OUT  
Anti COLL  UP

**Positions readout from the low-level**

Motor ste... Left UP 4.651  
Jaw edges Right UP -4.999 Centre UP -0.174

Display jaw:  TOP (LU)  BOTTOM (RU)  
Positions:  Set  LVDT  Warn  Lim  Res  Motor  
BLM:  BLM 1  BLM 2  BLM 3  BLM 4  LogY  
Int. Time:  1.31s  655ms  81.9ms  10.2ms

**Views** [26/04/12 16:39:30]

Jaw positions [mm]

The graph shows jaw positions in millimeters over time. The y-axis ranges from 4.65 to 5.00 mm, and the x-axis ranges from 16:37:20 to 16:39:20. The data points show a step-like decrease in position over time, with a blue line labeled 'Setting' and a blue arrow labeled 'Motor' pointing to the data.

| Time [hh:mm:ss] | Jaw Position [mm] |
|-----------------|-------------------|
| 16:37:20        | 4.90              |
| 16:37:30        | 4.88              |
| 16:37:40        | 4.86              |
| 16:38:00        | 4.85              |
| 16:38:20        | 4.83              |
| 16:38:30        | 4.81              |
| 16:38:40        | 4.79              |
| 16:38:50        | 4.77              |
| 16:39:00        | 4.75              |
| 16:39:10        | 4.73              |
| 16:39:20        | 4.71              |

time [hh:mm:ss]

Console

```
14:13:04 - Start set-up for update of motor positions to LVDT readings
14:13:06 - Done!
```

14:10:35 - Ready.



# TOTEM: Test Examples



10  $\mu\text{m}$

LHC Collimator Control Application - Semi-Automatic Set-up V1 (Device: XRPV.A6L5.B2/45-220-N-T/B)

File Settings Reset More displays Help

Jaw corners Increment BBA

**Set increments of single jaw corners**

TOP (LU) [um]

BOTTOM (RU) [um]

Repeat  times every  sec.

Repeat option finished - 10/10 executed.

TOP (LU)  UP-IN  UP-OUT  
BOTTOM (R...  UP-IN  UP-OUT  
Anti COLL  UP

**Positions readout from the low-level**

Motor ste... Left UP 4.849  
Jaw edges Right UP -4.999 Centre UP -0.075

Display jaw:  TOP (LU)  BOTTOM (RU)  
Positions:  Set  LVDT  Warn  Lim  Res  Motor  
BLM:  BLM 1  BLM 2  BLM 3  BLM 4  LogY  
Int. Time:  1.31s  655ms  81.9ms  10.2ms

**Views** [26/04/12 16:37:54]

Jaw positions [mm]

time [hh:mm:ss]

Console

```
14:13:04 - Start set-up for update of motor positions to LVDT readings
14:13:06 - Done!
```

14:10:35 - Ready.



# Commissioning of the LVDT Bypass Boxes



- One key per experiment (ALFA, TOTEM) to
  - bypass LVDT input to interlock
  - and disable all pots at the same time.Key to be kept in the CCC.
- Vertical key position :
  - LVDT Position interlock active,
  - RP motors can be enabled.
- Diagonal key position :
  - LVDT Position interlock bypassed,
  - RP motor power disabled by hardware link

Circuit diagrams in EDMS 1183242 by Xavier Pons.

ALFA and TOTEM: boxes now operational.

Tests done on 25 April.

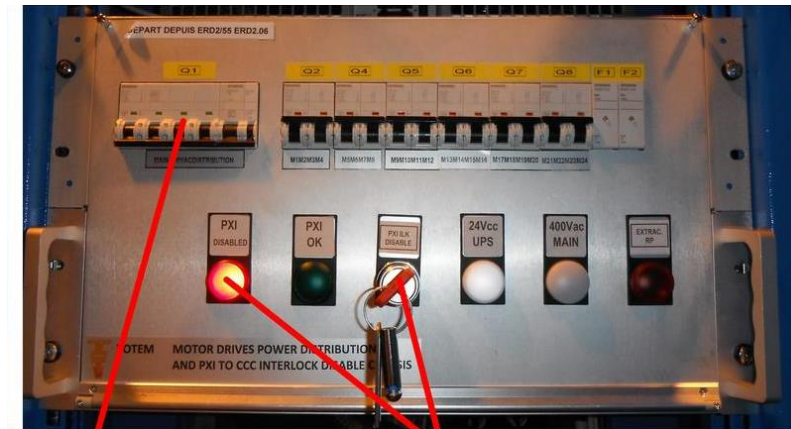
- TOTEM: LHC COLL logbook:  
<https://ab-dep-op-elogbook.web.cern.ch/ab-dep-op-elogbook/elogbook/secure/eLogbook.php?shiftId=1043476>  
EDMS 1204523 (interlock test report) updated !
- ALFA: LHC OP logbook:  
<https://ab-dep-op-elogbook.web.cern.ch/ab-dep-op-elogbook/elogbook/secure/eLogbook.php?shiftId=1043460>

TOTEM LVDT Bypass Box



main power switches up

interlock disable off



main power switches down

interlock disable on

# ALFA LVDT Bypass Box Modification

ALFA. Before technical stop:  
4 individual keys for LVDT comparison  
override.



ALFA. Now:

1 key for override all LVDT comparison.  
The key also cut the power to the motors.



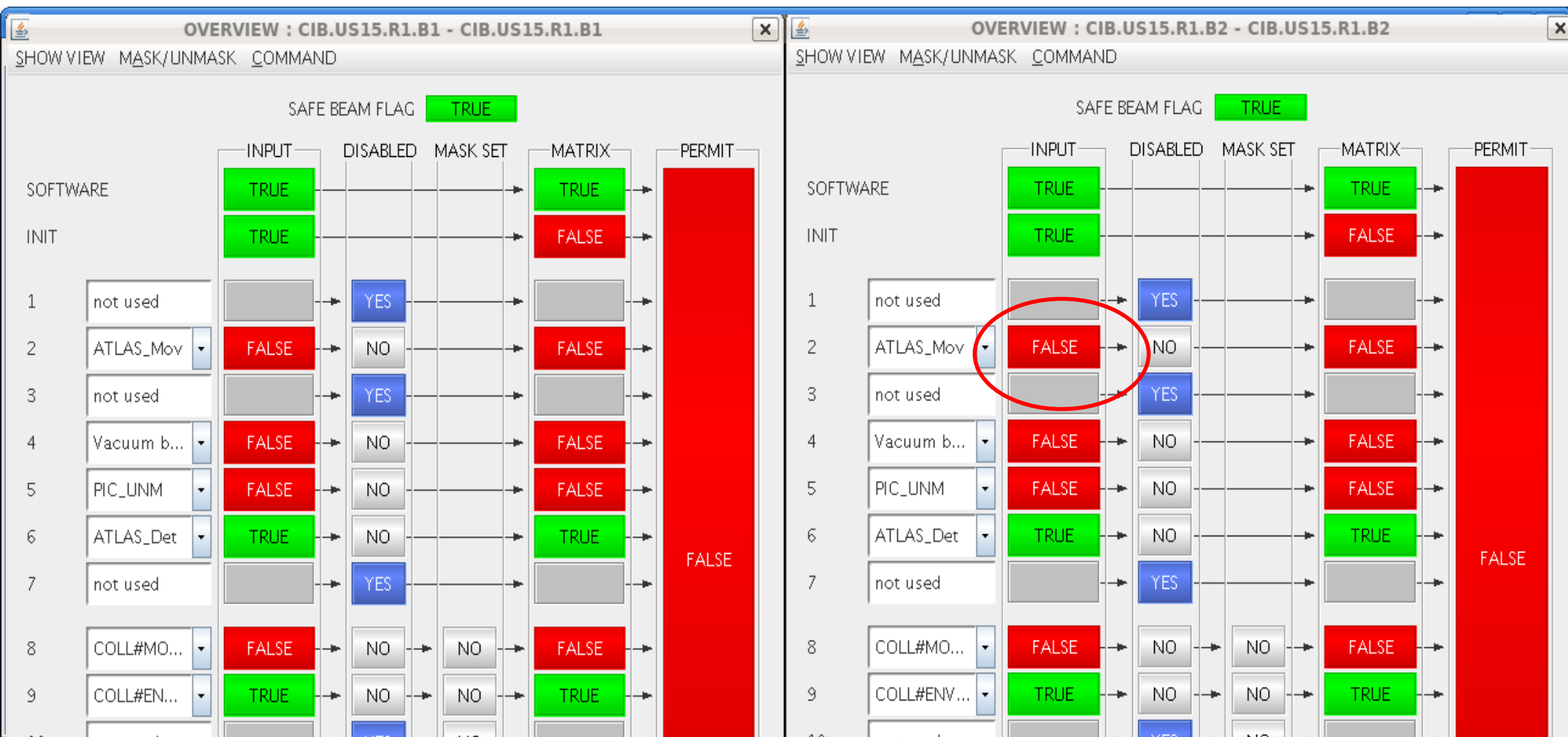
## Test 1 (Failure during TOTEM / ALFA Run)

- 1) RPs are near the beam.
- 2) Simulate failure: Switch PXI crate off → dump, RP extraction
- 3) Turn BYPASS on → USER\_PERMIT back, RP motors disabled.  
[LHC can operate without RPs while repairs are done]
- 4) Restart PXI and its processes.  
Verify that no RP movement is possible.
- 5) Turn BYPASS off and re-enable the motors.
- 6) Check normal functionality of RP movements and interlocks

# ALFA. Bypass key test. Wednesday 25th

## TEST 1, sequence 2.

- 8:37 ALL pots at 20mm (upper) and -35mm (lower)
- 9:21 switch off PXI. Dump and extraction. **User\_Permit gone**



The image shows two side-by-side screenshots of a control interface, likely for a particle accelerator. Both windows are titled "OVERVIEW : CIB.US15.R1.B1 - CIB.US15.R1.B1" and "OVERVIEW : CIB.US15.R1.B2 - CIB.US15.R1.B2". The interface displays a table of parameters for various components, including SOFTWARE, INIT, and numbered rows (1-9). The columns are labeled INPUT, DISABLED, MASK SET, MATRIX, and PERMIT. The SAFE BEAM FLAG is set to TRUE in both windows. The PERMIT column is highlighted in red and contains the word "FALSE".

| Component | INPUT       | DISABLED | MASK SET | MATRIX | PERMIT |
|-----------|-------------|----------|----------|--------|--------|
| SOFTWARE  | TRUE        |          |          | TRUE   | FALSE  |
| INIT      | TRUE        |          |          | FALSE  |        |
| 1         | not used    | YES      |          |        |        |
| 2         | ATLAS_Mov   | NO       |          | FALSE  |        |
| 3         | not used    | YES      |          |        |        |
| 4         | Vacuum b... | NO       |          | FALSE  |        |
| 5         | PIC_UNM     | NO       |          | FALSE  |        |
| 6         | ATLAS_Det   | NO       |          | TRUE   |        |
| 7         | not used    | YES      |          |        |        |
| 8         | COLL#MO...  | NO       | NO       | FALSE  |        |
| 9         | COLL#EN...  | NO       | NO       | TRUE   |        |



# ALFA. Bypass key test. Wednesday 25th

## TEST 1, sequence 3.

- ALFA BYPASS key turned at 9:48. **USER\_Permit back**. No changes in the Application window (no traces). Trying to move triggers message: "no acknowledgement from PXI".

**OVERVIEW : CIB.US15.R1.B1 - CIB.US15.R1.B1**

SAFE BEAM FLAG TRUE

| SOFTWARE | INPUT  | DISABLED   | MASK SET  | MATRIX   | PERMIT |
|----------|--|--|---|--|--------|
| INIT     | <span style="background-color: green; color: white; padding: 2px;">TRUE</span>                 |  |   | <span style="background-color: red; color: white; padding: 2px;">FALSE</span>  | FALSE  |
| 1        | not used   | <span style="background-color: blue; color: white; padding: 2px;">YES</span> |   |  |        |
| 2        | ATLAS_Mov <span style="border: 1px solid green; border-radius: 50%; padding: 2px;">TRUE</span> | <span style="background-color: gray; color: white; padding: 2px;">NO</span>  |   | <span style="background-color: green; color: white; padding: 2px;">TRUE</span> |        |
| 3        | not used   | <span style="background-color: blue; color: white; padding: 2px;">YES</span> |   |  |        |
| 4        | Vacuum b... <span style="background-color: red; color: white; padding: 2px;">FALSE</span>      | <span style="background-color: gray; color: white; padding: 2px;">NO</span>  |   | <span style="background-color: red; color: white; padding: 2px;">FALSE</span>  |        |
| 5        | PIC_UNM <span style="background-color: red; color: white; padding: 2px;">FALSE</span>          | <span style="background-color: gray; color: white; padding: 2px;">NO</span>  |   | <span style="background-color: red; color: white; padding: 2px;">FALSE</span>  |        |
| 6        | ATLAS_Det <span style="background-color: green; color: white; padding: 2px;">TRUE</span>       | <span style="background-color: gray; color: white; padding: 2px;">NO</span>  |   | <span style="background-color: green; color: white; padding: 2px;">TRUE</span> |        |
| 7        | not used   | <span style="background-color: blue; color: white; padding: 2px;">YES</span> |   |  |        |
| 8        | COLL#MO... <span style="background-color: red; color: white; padding: 2px;">FALSE</span>       | <span style="background-color: gray; color: white; padding: 2px;">NO</span>  | <span style="background-color: gray; color: white; padding: 2px;">NO</span> | <span style="background-color: red; color: white; padding: 2px;">FALSE</span>  |        |
| 9        | COLL#EN... <span style="background-color: green; color: white; padding: 2px;">TRUE</span>      | <span style="background-color: gray; color: white; padding: 2px;">NO</span>  | <span style="background-color: gray; color: white; padding: 2px;">NO</span> | <span style="background-color: green; color: white; padding: 2px;">TRUE</span> |        |
| 10       | not used   | <span style="background-color: blue; color: white; padding: 2px;">YES</span> | <span style="background-color: gray; color: white; padding: 2px;">NO</span> |  |        |

**OVERVIEW : CIB.US15.R1.B2 - CIB.US15.R1.B2**

SAFE BEAM FLAG TRUE

| SOFTWARE | INPUT  | DISABLED   | MASK SET  | MATRIX   | PERMIT |
|----------|--|--|---|--|--------|
| INIT     | <span style="background-color: green; color: white; padding: 2px;">TRUE</span>             |  |   | <span style="background-color: red; color: white; padding: 2px;">FALSE</span>  | FALSE  |
| 1        | not used   | <span style="background-color: blue; color: white; padding: 2px;">YES</span> |   |  |        |
| 2        | ATLAS_Mov <span style="background-color: green; color: white; padding: 2px;">TRUE</span>   | <span style="background-color: gray; color: white; padding: 2px;">NO</span>  |   | <span style="background-color: green; color: white; padding: 2px;">TRUE</span> |        |
| 3        | not used   | <span style="background-color: blue; color: white; padding: 2px;">YES</span> |   |  |        |
| 4        | Vacuum b... <span style="background-color: red; color: white; padding: 2px;">FALSE</span>  | <span style="background-color: gray; color: white; padding: 2px;">NO</span>  |   | <span style="background-color: red; color: white; padding: 2px;">FALSE</span>  |        |
| 5        | PIC_UNM <span style="background-color: red; color: white; padding: 2px;">FALSE</span>      | <span style="background-color: gray; color: white; padding: 2px;">NO</span>  |   | <span style="background-color: red; color: white; padding: 2px;">FALSE</span>  |        |
| 6        | ATLAS_Det <span style="background-color: green; color: white; padding: 2px;">TRUE</span>   | <span style="background-color: gray; color: white; padding: 2px;">NO</span>  |   | <span style="background-color: green; color: white; padding: 2px;">TRUE</span> |        |
| 7        | not used   | <span style="background-color: blue; color: white; padding: 2px;">YES</span> |   |  |        |
| 8        | COLL#MO... <span style="background-color: red; color: white; padding: 2px;">FALSE</span>   | <span style="background-color: gray; color: white; padding: 2px;">NO</span>  | <span style="background-color: gray; color: white; padding: 2px;">NO</span> | <span style="background-color: red; color: white; padding: 2px;">FALSE</span>  |        |
| 9        | COLL#ENV... <span style="background-color: green; color: white; padding: 2px;">TRUE</span> | <span style="background-color: gray; color: white; padding: 2px;">NO</span>  | <span style="background-color: gray; color: white; padding: 2px;">NO</span> | <span style="background-color: green; color: white; padding: 2px;">TRUE</span> |        |
| 10       | not used   | <span style="background-color: blue; color: white; padding: 2px;">YES</span> | <span style="background-color: gray; color: white; padding: 2px;">NO</span> |  |        |

## Test 1 (Failure during TOTEM / ALFA Run)

- 1) RPs are near the beam.
- 2) Simulate failure: Switch PXI crate off → dump, RP extraction
- 3) Turn BYPASS on → USER\_PERMIT back, RP motors disabled.  
[LHC can operate without RPs while repairs are done]
- 4) Restart PXI and its processes.  
Verify that no RP movement is possible.
- 5) Turn BYPASS off and re-enable the motors.
- 6) Check normal functionality of RP movements and interlocks

## Test 2 (“The Forbidden Use Case”) [tested only for completeness]

- 1) RPs are near the beam.  
[Imagine PXI is stuck and needs reboot]
- 2) Turn BYPASS on
- 3) Reboot PXI → no dump  
Verify that no RP movement is possible
- 4) Turn BYPASS off and re-enable the RP motors.
- 5) Check normal RP functionality

# Bypass Box Test 2: ALFA

LHC Collimator Control

RBA: deile

File Settings Reset More displays Help

Jaw corners Increment

**Set single motor positions**

TOP (LU) [um]

BOTTOM (RU) [um]

Asking new jaw positions

TOP (LU)  UP-IN  UP-OUT

BOTTOM (R...  UP-IN  UP-OUT

Anti COLL  UP

Position

LVDT's

Right UP -44.268 Centre UP -1.832

Display jaw:  TOP (LU)  BOTTOM (RU)

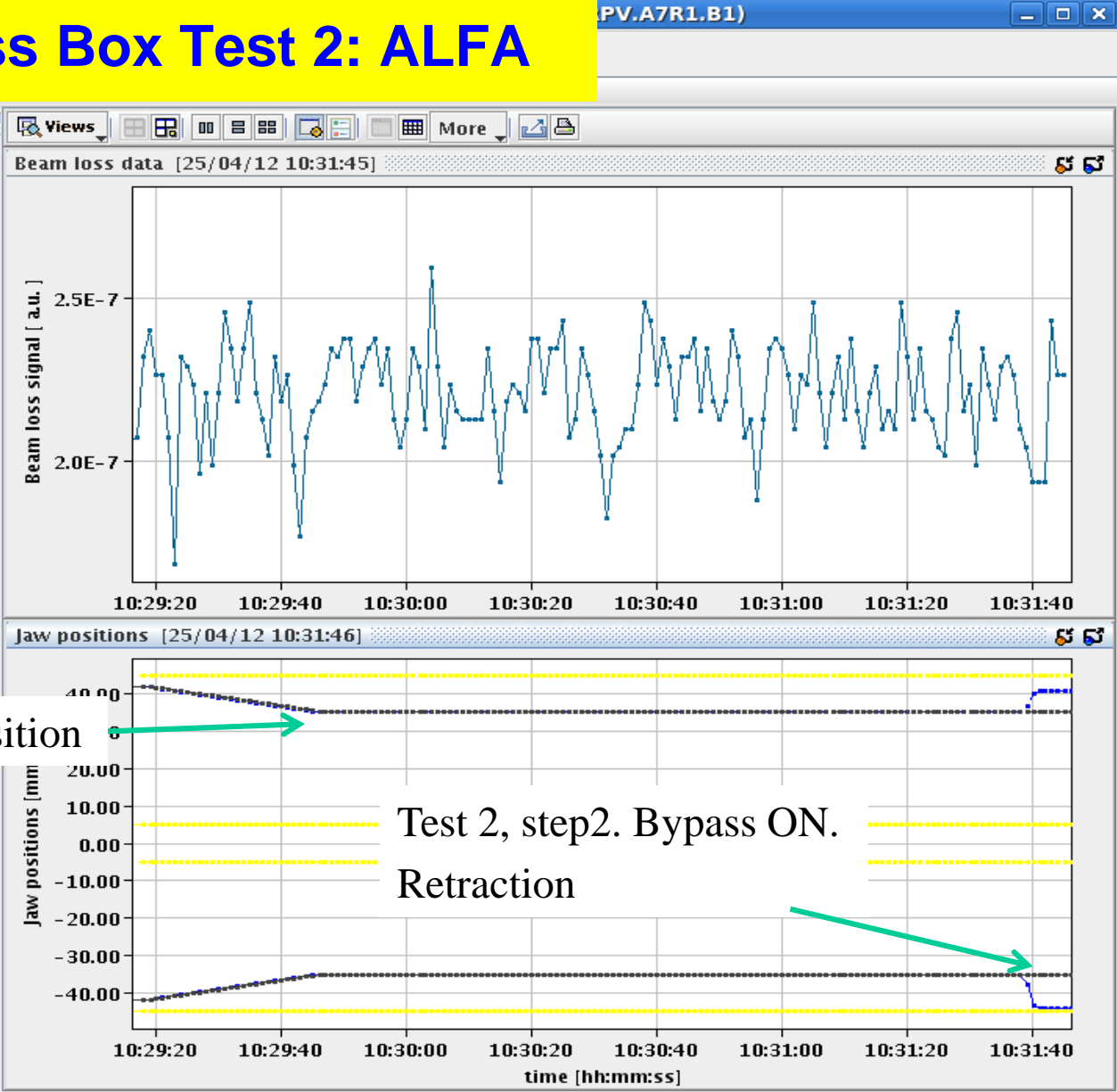
Positions:  Set  LVDT  Warn  Lim  Res  Motor

BLM:  BLM 1  BLM 2  BLM 3  BLM 4  LogY

Console

```
10:28:32 - Start set-up for update of motor positions to LVDT readings
10:28:34 - Done!
```

08:17:12 - Ready.



ATLAS

## Test 3 (“Holiday Mode”)

- 1) All pots are in garage (at HOME switch)
- 2) Turn **BYPASS** on  
Verify that no RP movement is possible
- 3) Turn **BYPASS** off and re-enable the RP motors
- 4) Check normal RP functionality

## Test 4 (Failure while TOTEM/ALFA in Standby – “When the CCC calls in the night...”)

- 1) All pots are in garage (at HOME switch)
- 2) **Simulate failure: Switch PXI crate off** → dump, RP extraction
- 3) Turn **BYPASS** on → **USER\_PERMIT** back, RP  
motors disabled  
[LHC can operate without RPs while repairs are done]
- 4) **Restart PXI and its processes**  
Verify that no RP movement is possible
- 5) Turn **BYPASS** off and re-enable the RP motors
- 6) Check normal RP functionality

# Improvements of the CCC Application



## Done (thanks to Gianluca and Stefano):

- Fixed the broken STOP button in the BBA version of the RP-collimator application
- Configured the button “Out Switches” to send the pots to the OUT Stopper positions
- Included BBA version in the LHC menu tree  
(no more confusion about versions and typing explicit web URLs)
- Tested driving pre-defined open “parking” limits with EquipState (easier and less error prone)

## Medium Term Wishes:

- Display new inner limits as curves
- Add the BBA tab to the default version (reachable via the LHC menu)

## Long Term Wishes:

- Naming conventions for existing button display:  
UP-IN      UP-OUT      →      IN-Stopper      HOME
- Add another button for the real OUT Stopper
- Display difference between motor and LVDT (as a number)
- Human-understandable error messages (presently “java ...” over ~20 lines)

# Backup



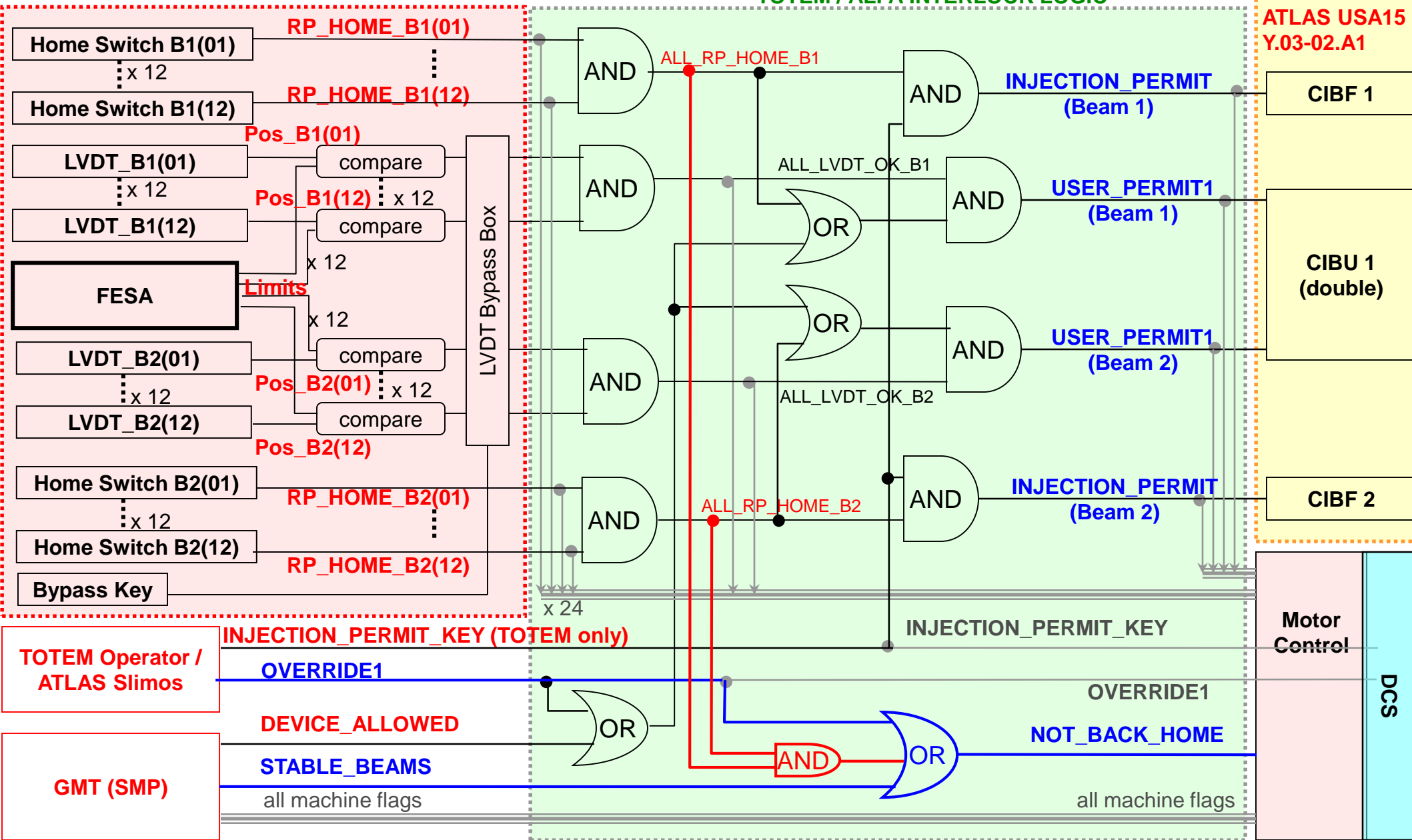


# Interlock Logic 2012

## IN MOTOR CONTROL RACK

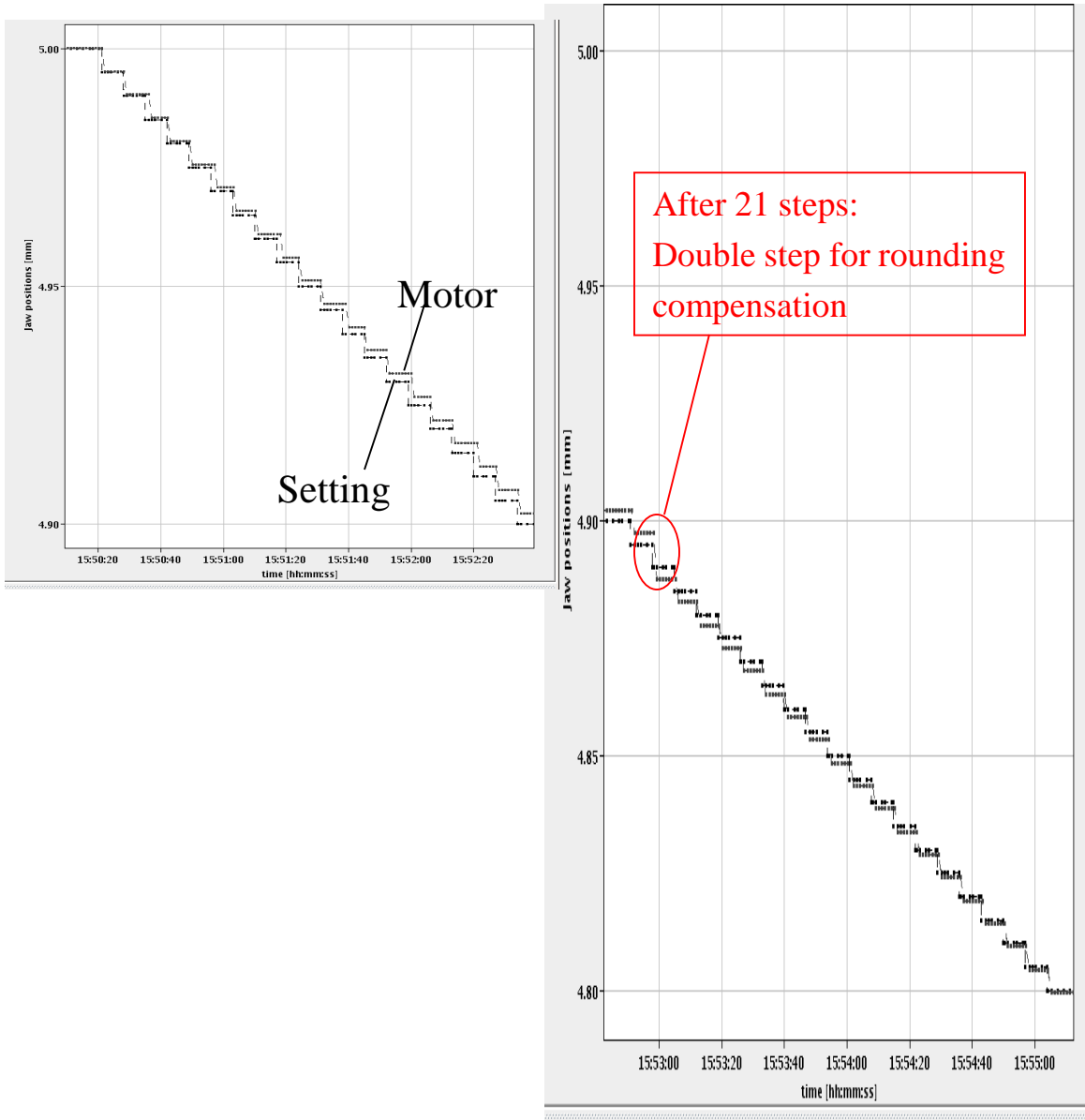
## TOTEM / ALFA INTERLOCK LOGIC

CMS S1E08 /  
ATLAS USA15  
Y.03-02.A1



# Examples for 5 $\mu$ m Movements

Very good case: initial deviation  $\sim 0$



Worse case: initial deviation  $\sim 5 \mu\text{m}$   
→ Rounding produces steps of 0 or 10  $\mu\text{m}$

