Special MPP meeting on MP aspects of Roman pot operation

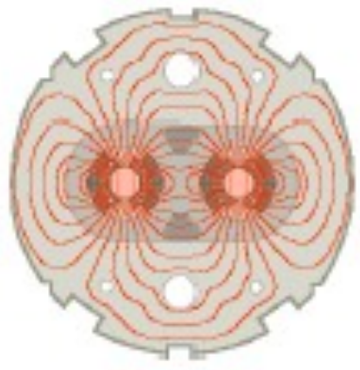
December 2nd, 2011

CERN, Geneva, Switzerland

Roman pots: Operational procedures

S. Redaelli, BE-OP

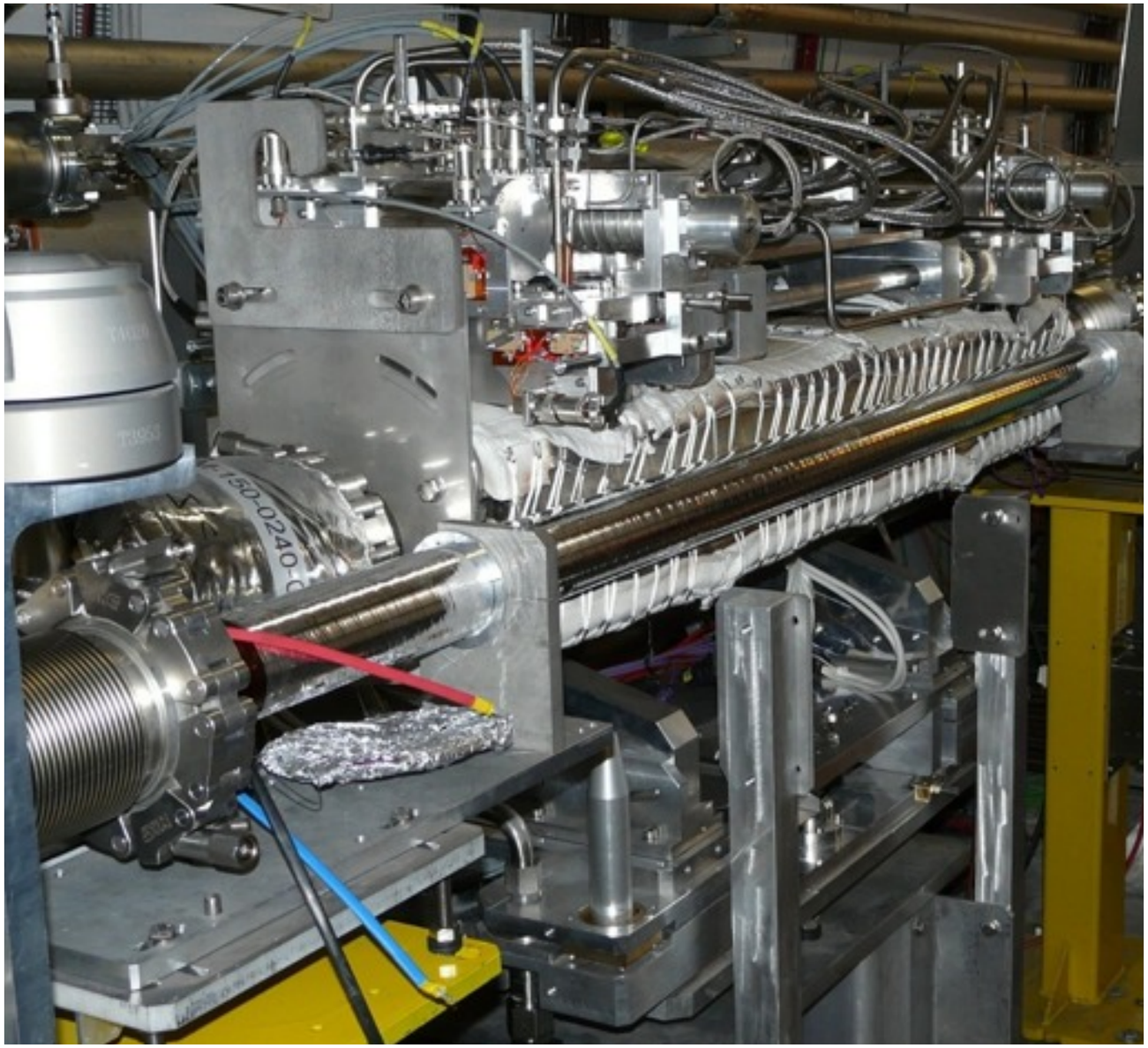
Inputs from: R. Assmann, M. Lamont, J. Wenninger, TOTEM and ALFA teams

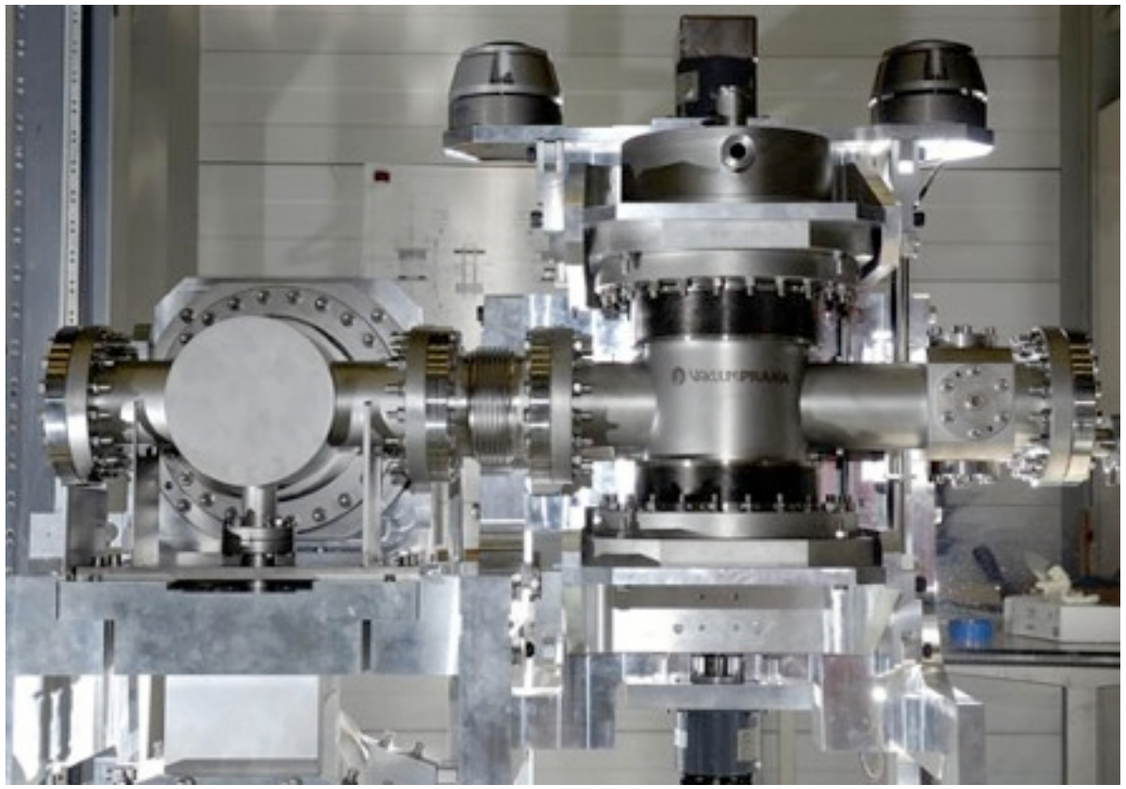


Outline

- Introduction
- Recap. of controls aspects
- Operational procedures
- Various observations
- Conclusions

Introduction





Is a Roman pot a collimator?

... yes and no!

Roman pot controls strategy

A Roman pot is a collimator to the extend that:
- It must respect the **collimator hierarchy**
- Can be very close to the beam (< 5 mm)
- It needs the same beam-based alignment
- Its interlocking strategy must respect the standards by imposed by MP

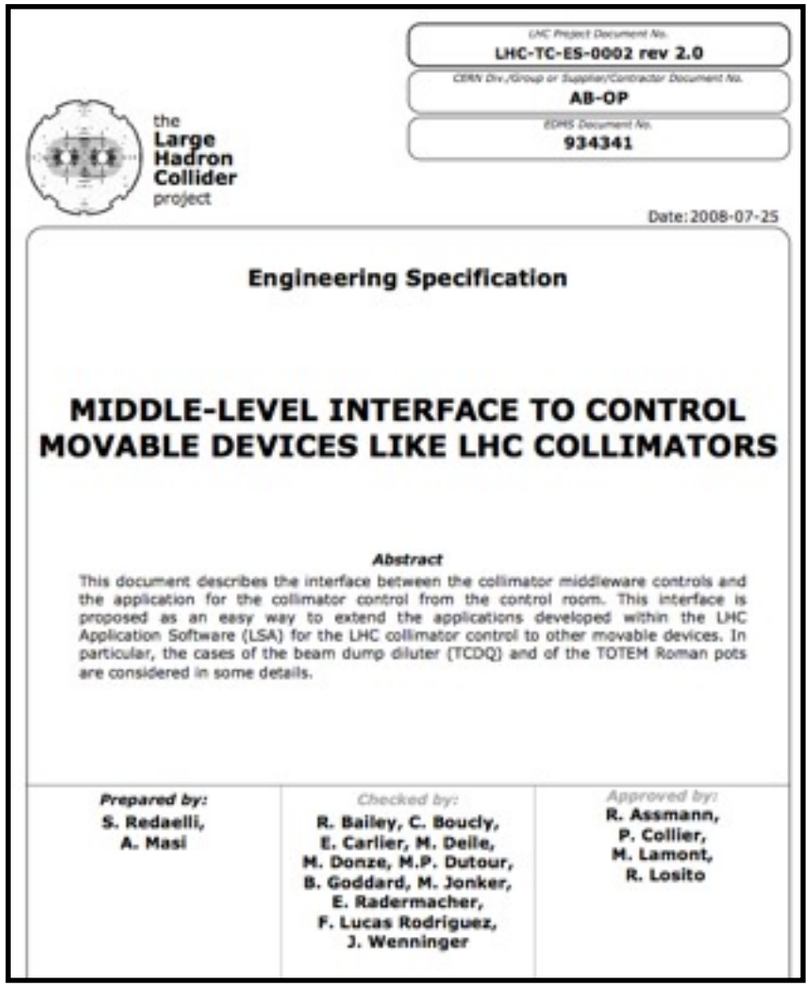
General operation approach (until 2007)

Movements under responsibility of the machine (OP: CCC app + setting management)

Minimum allowed settings defined by collimation project

Try derive architecture from collimator controls

Since summer 2007, under request of OP GL (P. Collier):
1. Confirmed OP responsibility for movements, from CCC
2. Specified a common interface for the middle-ware controls for a “transparent” operation from the CCC
3. HW commissioning and interlock validation clearly under the responsibility of TOTEM + ATLAS (input+help from collimation, MP and OP teams)
4. Critical limits under responsibility of Coll Team



LHC Project Document No.
LHC-TC-ES-0002 rev 2.0
CERN Div./Group or Supplier/Contractor Document No.
AB-OP
EDMS Document No.
934341

the Large Hadron Collider project

Date: 2008-07-25

Engineering Specification

MIDDLE-LEVEL INTERFACE TO CONTROL MOVABLE DEVICES LIKE LHC COLLIMATORS

Abstract

This document describes the interface between the collimator middleware controls and the application for the collimator control from the control room. This interface is proposed as an easy way to extend the applications developed within the LHC Application Software (LSA) for the LHC collimator control to other movable devices. In particular, the cases of the beam dump diluter (TCDQ) and of the TOTEM Roman pots are considered in some details.

Prepared by:	*Checked by:*	*Approved by:*
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Differences collimators / Roman pots

	Collimators	Roman pots
Profile execution	Functions + discrete	Discrete
Interlock limits (t)	Functions + discrete	Discrete
Redundant limits	Functions of energy and β^*	Additional “inner” limits
Connection to timing	Yes (HW trigger)	No (SW trigger)
Interlocked sensors	6 LVDTs for 4 axes	1 LVDT for 1 axis
Redundant sensors	4 resolvers	/
Controls redundancy	2 PXI’s per 1-3 collimator	1 PXI for 24 pots
Motor speed	2 mm/s	0.25 mm/s
Motion conditioned by machine mode	No	Yes: only if Stable Beams and MDA
OVERRIDE KEY	No	Yes
Motor reset procedure	~ 1 per year	1 per fill!

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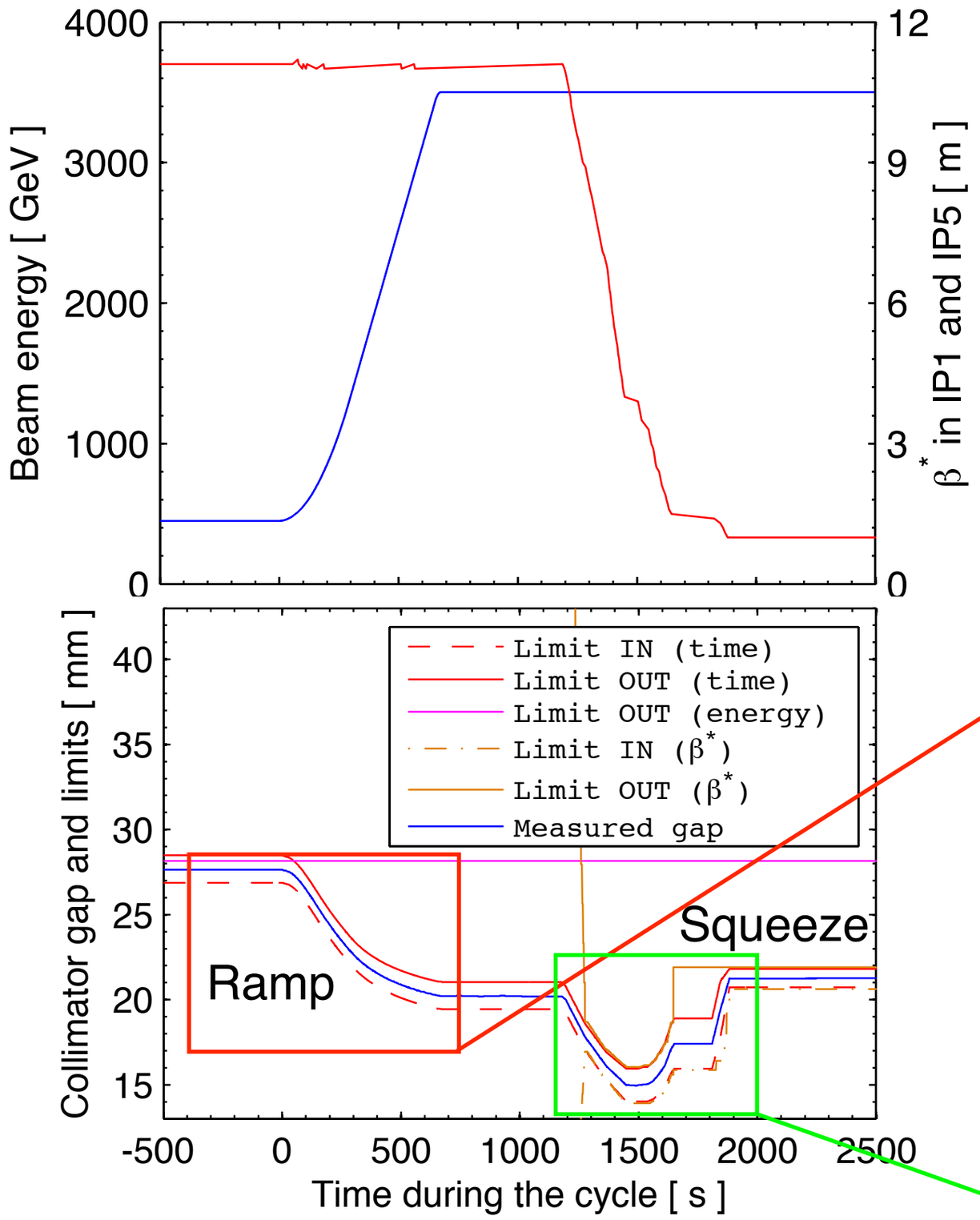
OVERRIDE KEY	No	Yes
Motor reset procedure	~ 1 per year	1 per fill!

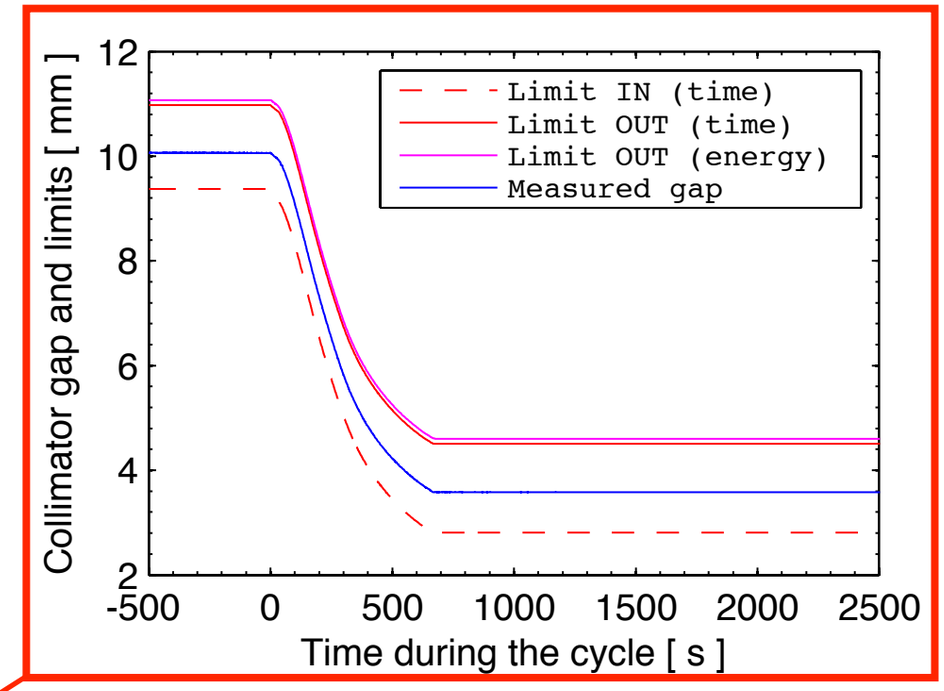
OVERRIDE KEY allows movements in all modes but does NOT by-pass position interlocks (beams dumped in all conditions if limits reached)

Additional protection mechanisms:
BLM *[other movable detectors like VELO rely only on that!]*
SIS checks of orbit

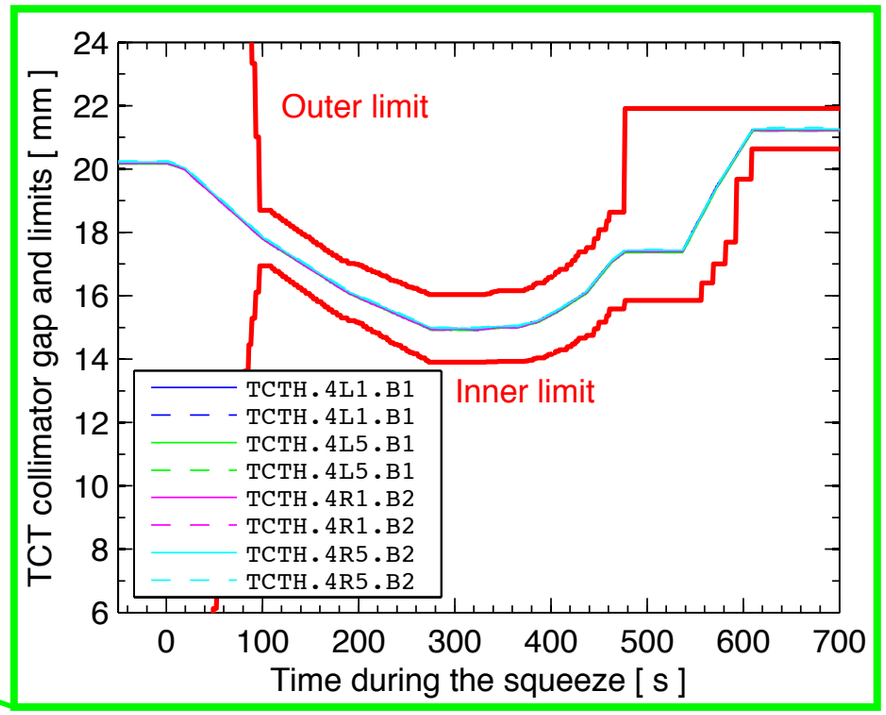
Collimator operational cycle



Energy ramp of a primary collimator



Squeeze for tertiary collimators

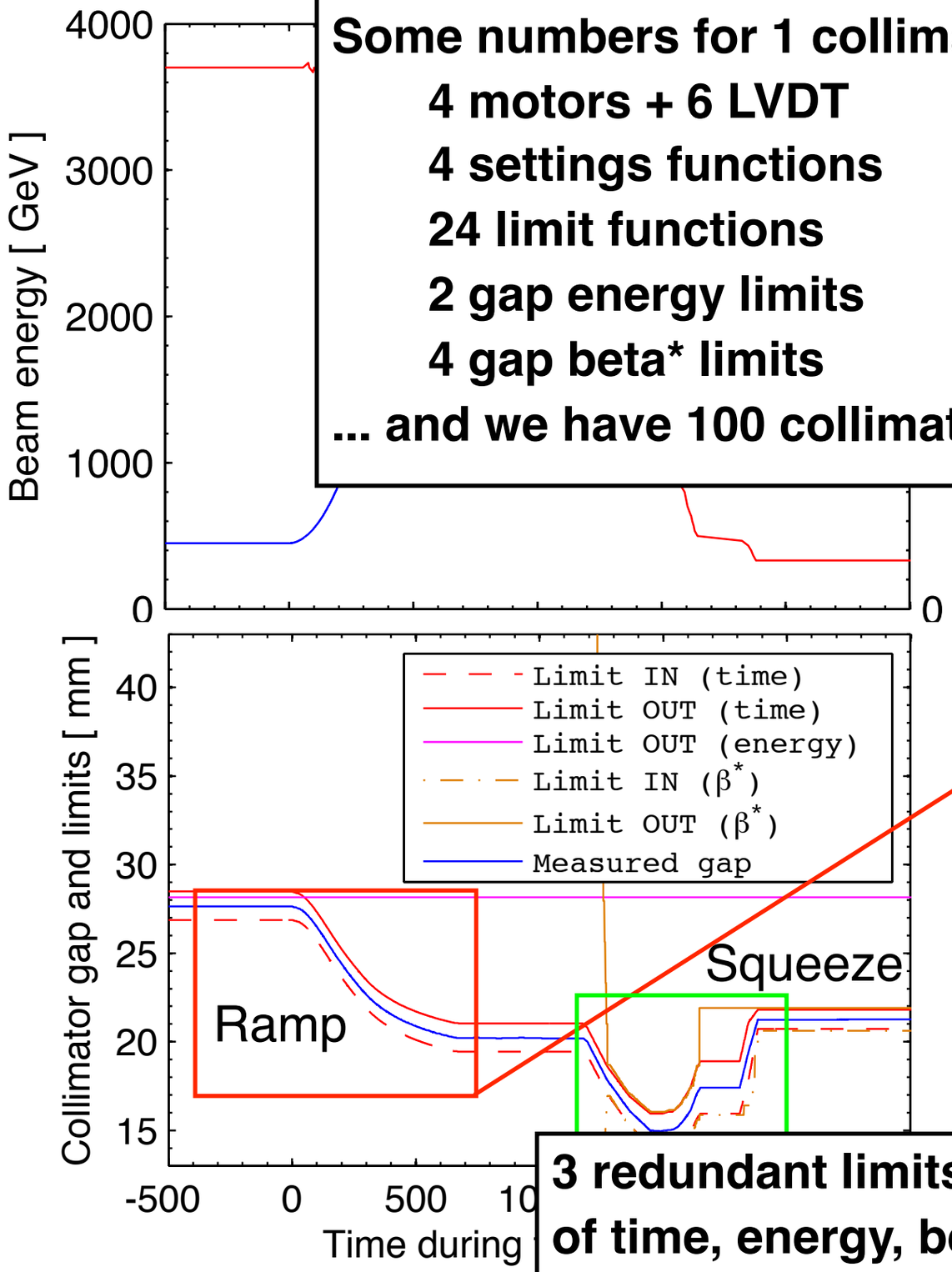


Collimator operational cycle

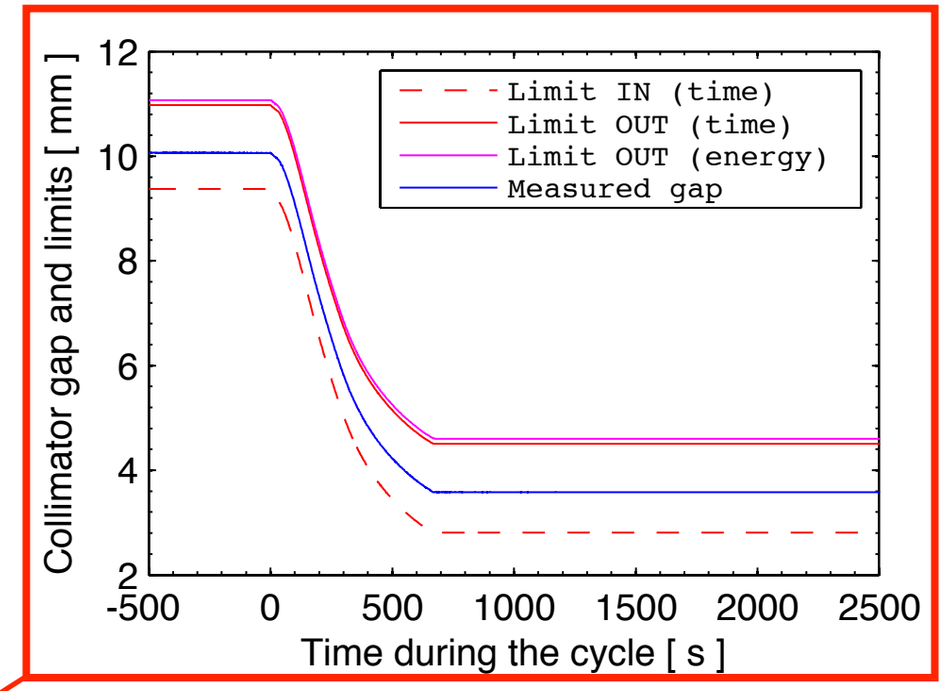
Some numbers for 1 collimator:

- **4 motors + 6 LVDT**
- **4 settings functions**
- **24 limit functions**
- **2 gap energy limits**
- **4 gap beta* limits**

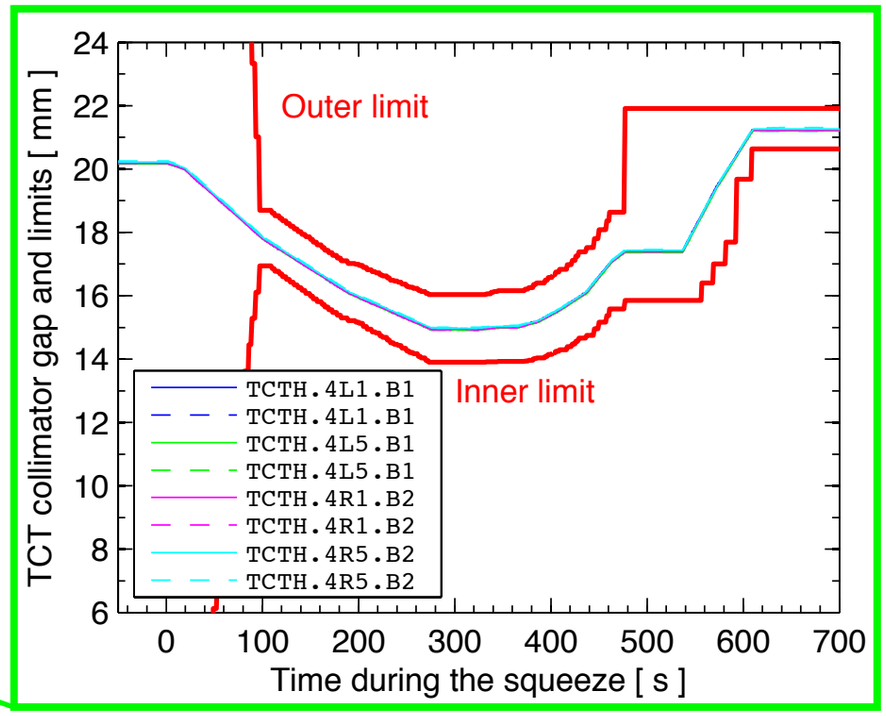
... and we have 100 collimators



Energy ramp of a primary collimator

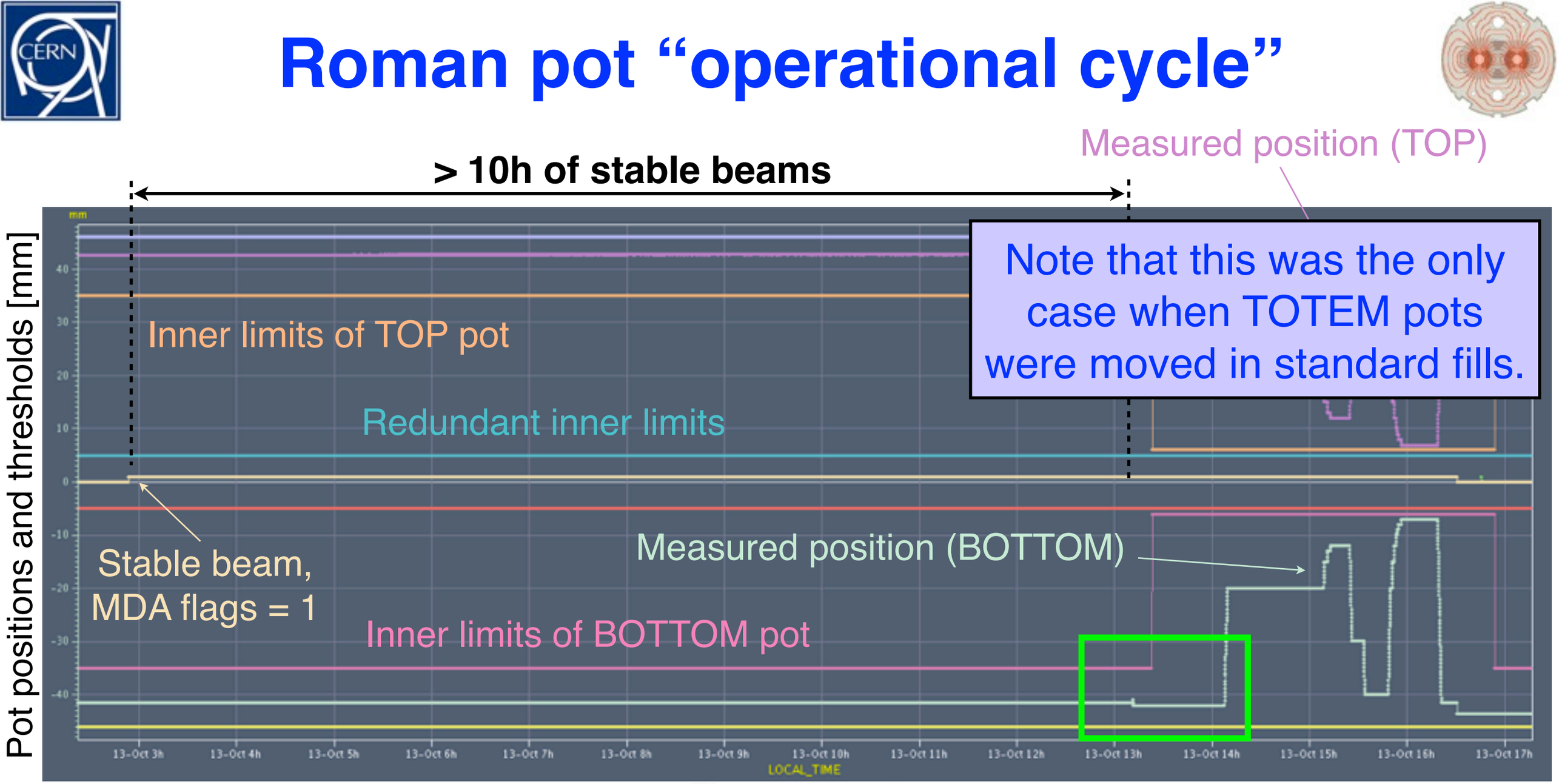


Squeeze for tertiary collimators



3 redundant limits (functions of time, energy, beta*) always active in parallel.

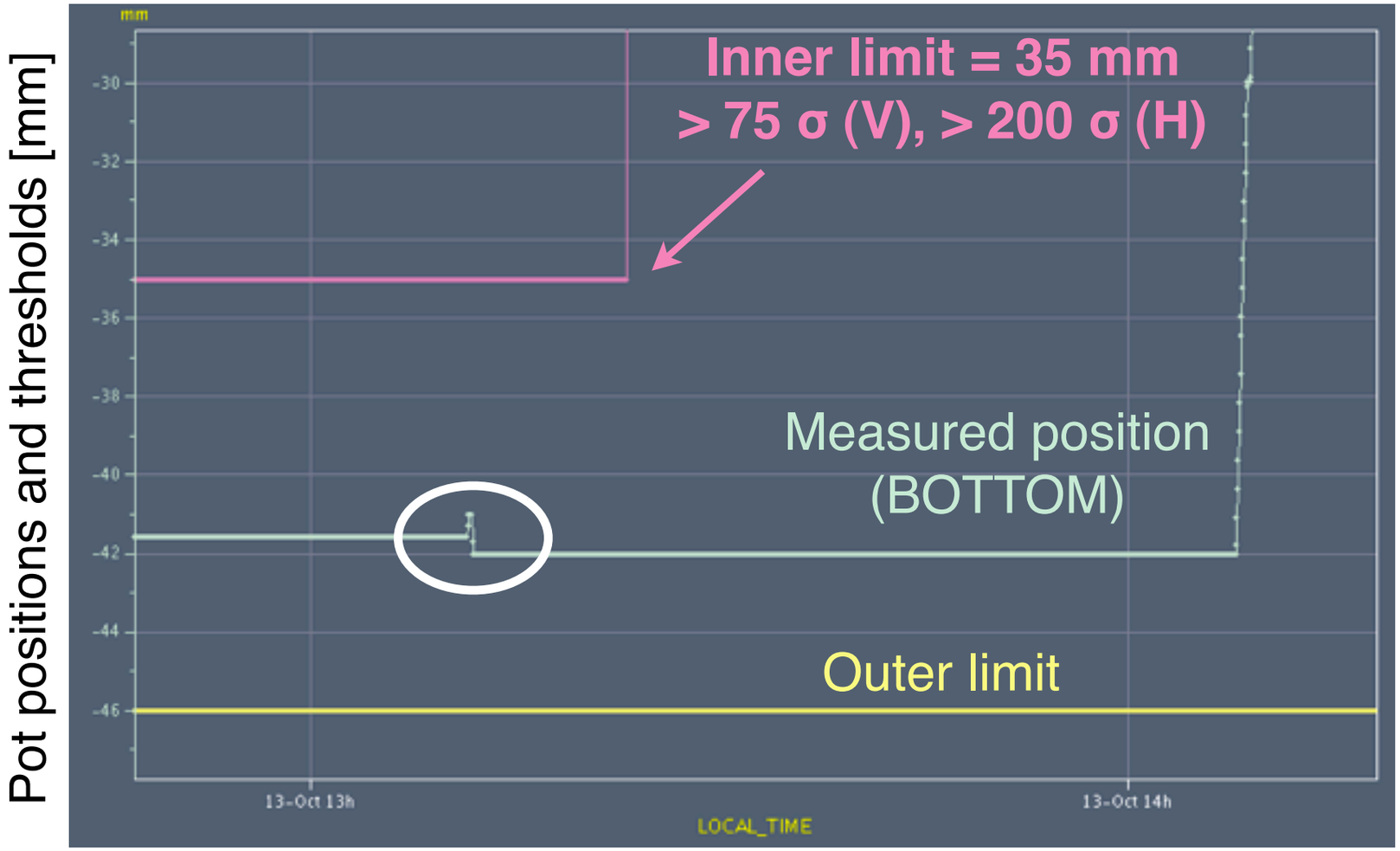
Roman pot "operational cycle"



0. Until **`StableBeams`** & **`MovableDevicesAllowed`** == TRUE, no movements:
   Movement inhibit + operational limits compatible with OUT positions.
1. Motor RESET done as a first step, for each pot (in **`StableBeams`** mode)
2. Pre-defined discrete limits to allow movements are loaded to the HW
3. Pots are moved to physics settings (individually or all together)

Note that "redundant inner limits" remain unchanged all the time

Roman pot reset procedure



RESET procedure added for the 2011 operation, to remove an issue with the feedback between motors and LVDTs:

Motor count is reset **before every fill** to a reference switch position.
Collimator: yearly calibration!

- RESET = low-level procedure triggered from the CCC but entirely implemented below.
- For high intensity fills: done in **`StableBeams`**, before opening the positions thresholds
  → *Beam dump if pot moved closer to the beam than 35 mm!*
- Can only be done only in **`StableBeams`** (or if the OVERRIDE key is TRUE)
- Could be easily put in sequences but it was done MANUALLY in 2011
  → *Manual check of positions is required, often the RESET fails and must be repeated*

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- Introduction
- Recap. of controls aspects
- **Operational procedures**
  - **Modes of operation**
  - **Operational procedures**
  - **Setting definition**
- Various observations
- Conclusions

Roman pot's modes of operation

Three different modes of operation:

1. Dedicated low-intensity fills for Roman pot alignment

Safe total intensities, done to establish reference orbit data

Settings validated by complete loss map campaigns

Done in collaboration with the collimation team

OVERRIDE = TRUE

PARKING LIMITS

2. Data taking during normal high intensity fills

Tasks required to move pots are in the nominal sequence:

freedom to move in the pre-defined safe boundaries

Movements done from the CCC with RP expert support

NOMINAL CONFIG:

OVERRIDE = FALSE

OP-DEFINED LIMITS

3. Special runs with low-intensity (ex. 90m optics)

Total intensity can be unsafe

Pots very close to the beam (< 5 sigmas), following a beam-based alignment

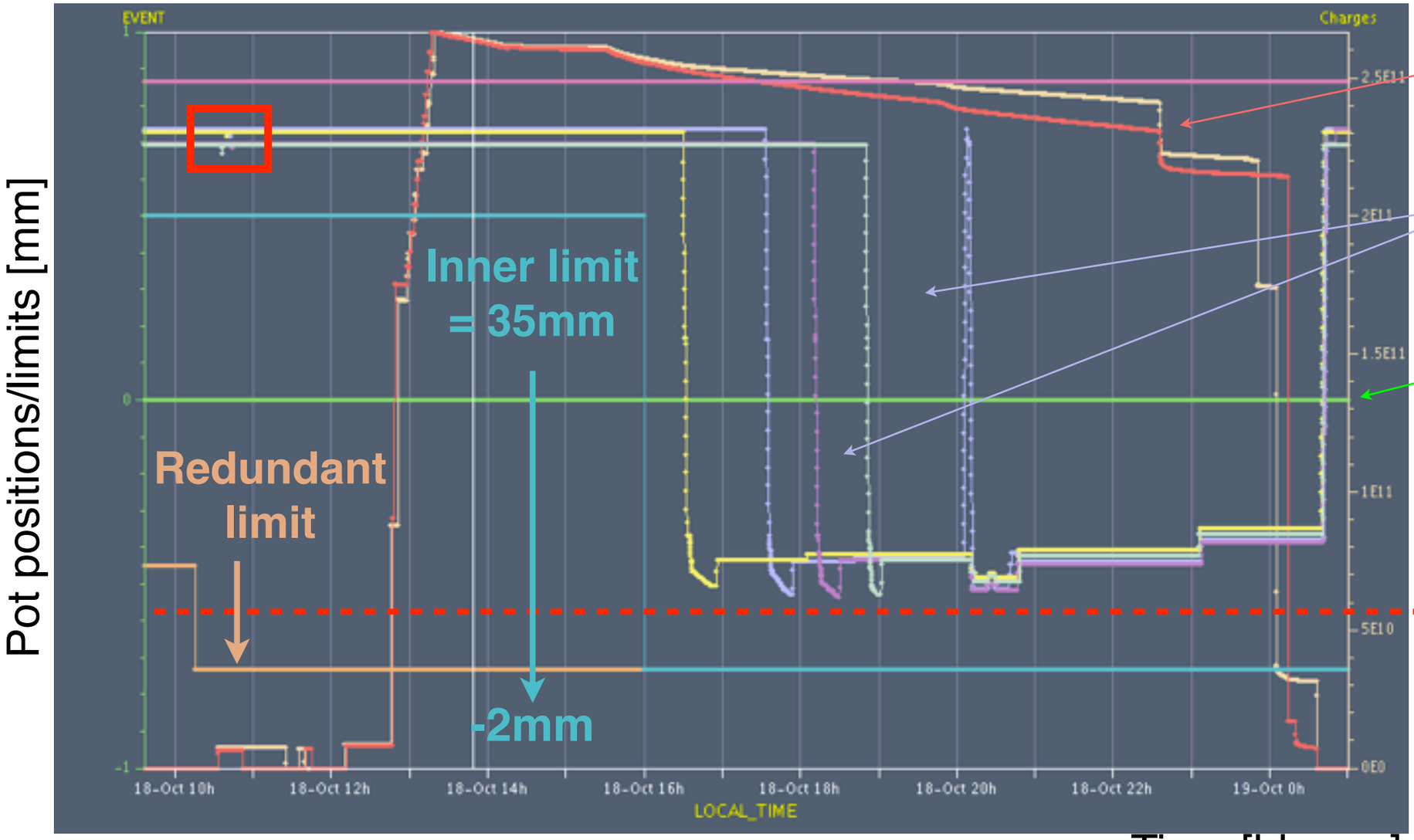
Special interlock config for intensities agreed with MP

Done by TOTEM/ALFA + collimation team

OVERRIDE = TRUE

PARKING LIMITS

Example of special operation run



Beam current

Roman pot positions

MDA flag FALSE

Indicative position of the beam

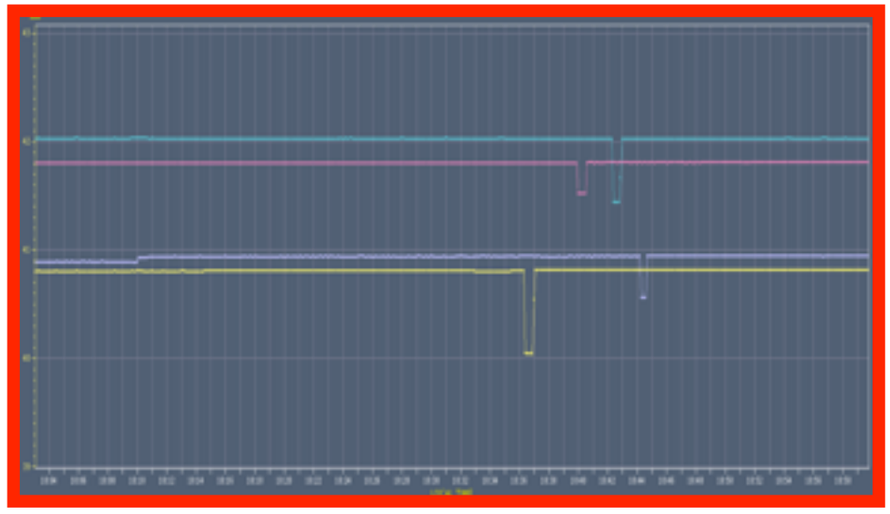
1 .Without beam: OVERRIDE set TRUE; RESET executed

2. Updated operational settings with open limits to parking

Positions across the beam orbit allowed in principle

3. Redundant limits also opened accordingly

4 .Injection, ramp and squeeze with pots locked OUT, open limits only when needed, in collision



Procedures for high-intensity fills

A. Fills with no Roman pot data taking:

- OP loads before injection the OUT position limits
- Outside **`StableBeams`**: movement inhibit + OUT positio
- Within **`StableBeams`**: only OUT position limits prevent r

Procedures were followed without problems. Until Nov. 6th...

B. Fills WITH Roman pots data taking:

0. Agreement between physics and machine coordinators
1. OP loads before injection the OUT position limits

   *Outside **`StableBeams`**: movement inhibit + OUT position limits*
2. A Roman pot expert goes to the CCC before data taking starts
3. In **`StableBeams`** the expert executes the RESET for all pots

   This must be done with pots close to or on the out switches
4. The EiC launches the sequence that loads the physics limits

   This allows pot positions within safe operational boundaries
5. Position settings are loaded and SW triggers can be sent

   All together or individually. Manual often preferred due to frequent hiccups
6. Pots are extracted by the expert at the end of the data taking or upon start of beam dump / adjust handshakes

Definition of safe operation limits

1. Collimation team defines minimum operational settings that respect the collimation hierarchy and MP constraints. Approved by MPP. Settings expressed in unit sigma.
2. One or more fills for the individual beam-based alignment of each Roman pot are performed (Coll + TOTEM + ALFA)
3. Settings in [mm] are calculated respecting (1)
4. Settings are validated for **`StableBeams`** with loss maps + asyn dump
5. Discrete limits and warnings are defined accordingly (e.g., 200-400 μm margin) and trimmed by Coll expert in the physics settings
6. Redundant inner limits are trimmed in the same way
7. Final values of settings + limits circulated to rMPP for checks/approval (cc: TOTEM, ALFA, OP and Coll team).

Note: only 2 sets of settings available through OP sequences. “Parking” limits are also available, well hidden in the controls system - but redundant inner limits cannot be changed by OP

Outline

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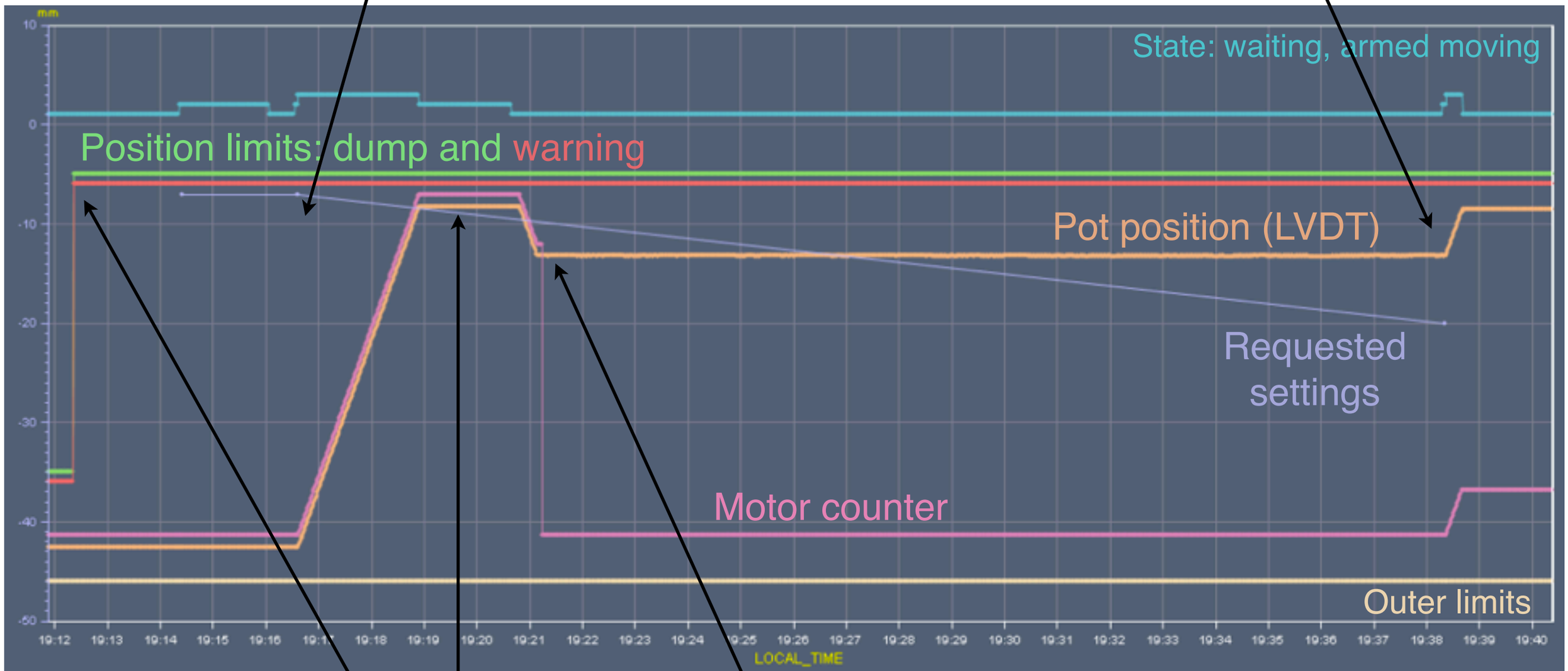
- ☑ Operational procedures
- ☑ **Various observations**
- ☑ Conclusions

Pot XRPV.A7L1.B2 on Nov. 6th, 2011

0. Turn “override” key to enable movements outside stable beams

2. Requested physics settings for loss maps: pot moves with 1.2 mm offset

5. Next movement request to 20mm moved pots towards the beam. Stopped manually.

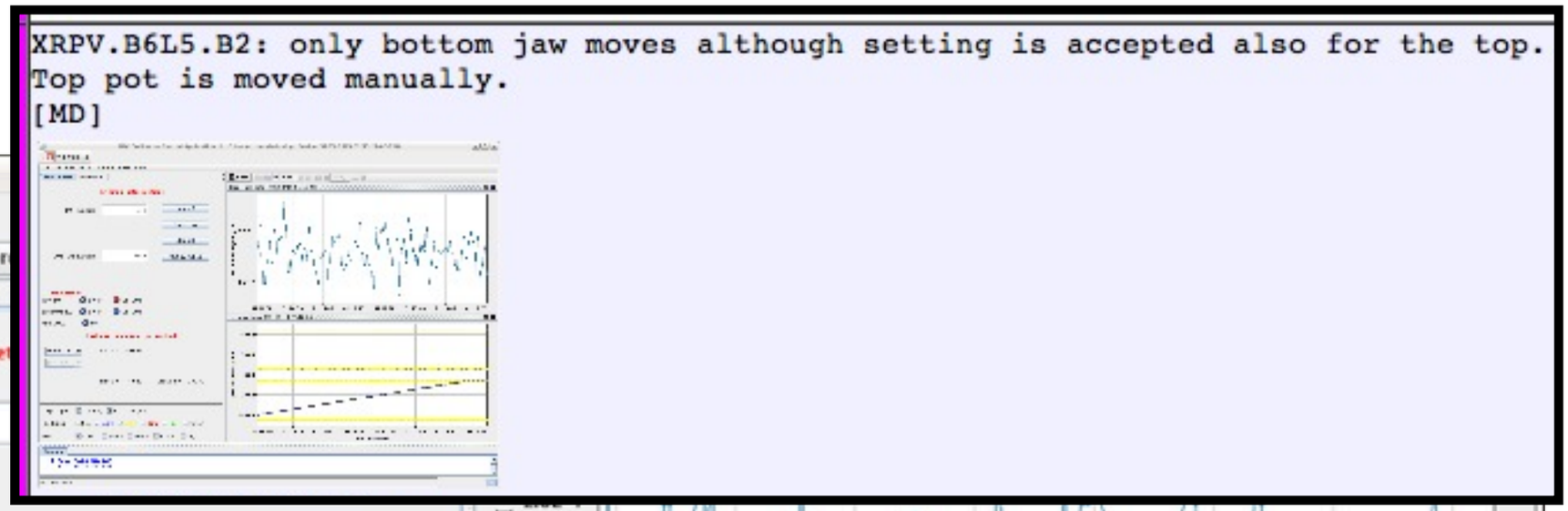


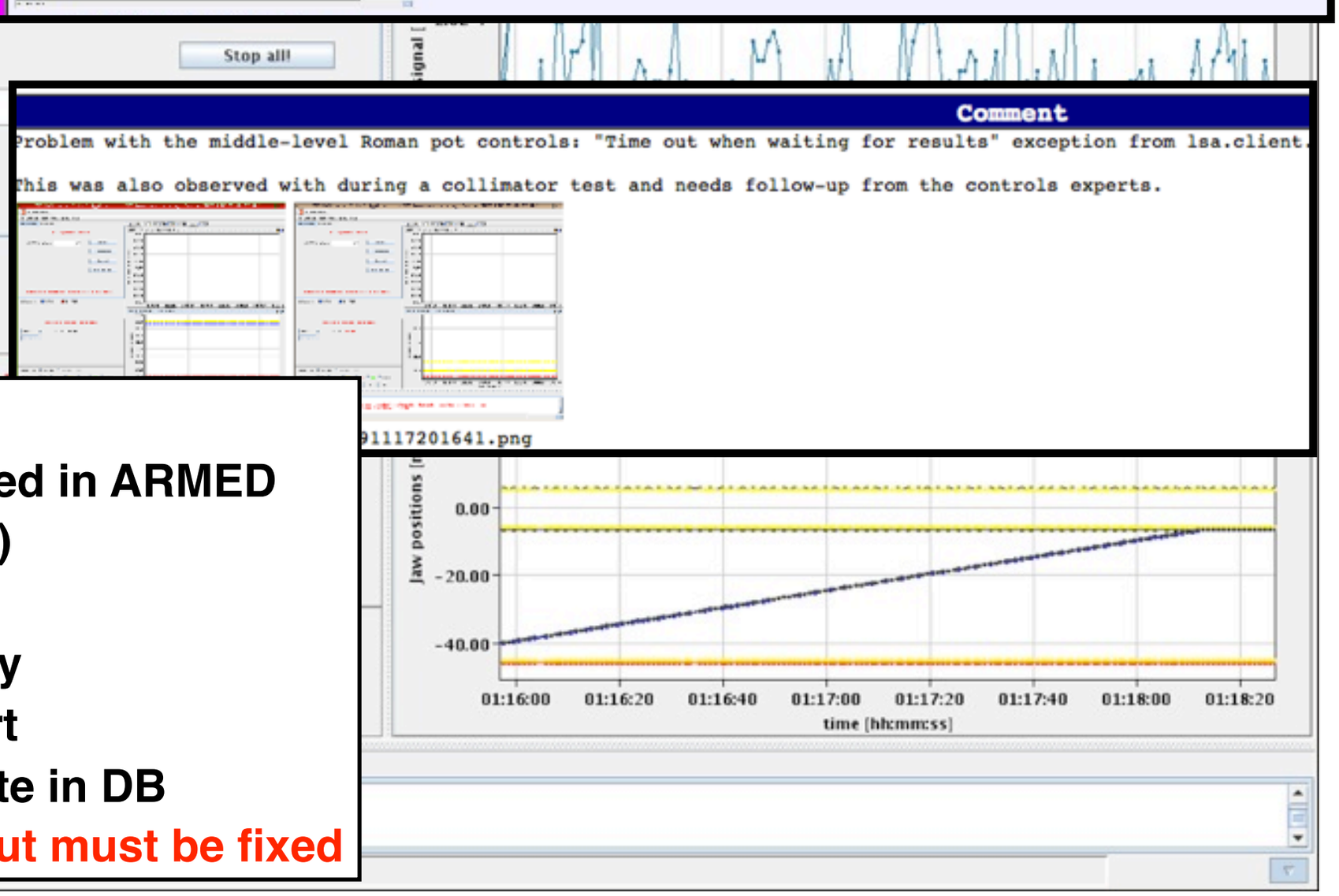
1. Open limits to physics settings (closest position allowed = 6.5mm > 17σ)

3. Attempt to move out failed

4. Requested RESET with pot in beam: it moves back by 5mm, does not find the switch BUT reset motor counter

Various reliability issues





Typical observations:

Individual pots remain blocked in ARMED state (do not take SW trigger)

Pots not moving at all

RESET not working at first try

Long timeouts setting -> start

Switches positions not update in DB

... No MP issue, but must be fixed

Conclusions

- **Reviewed operational aspects of LHC Roman pots**
  - *Roman pot are "like" the collimators, but there are differences!*
  - *Operational procedures are well established.*
- **Reduced redundancy → rely more on execution of sequences and on procedures**
  - *Ex.: how to enforce revert of limits after special runs*
- **RESET procedure is critical for pot operation**
  - *Can only be done manually so far. Not enforced, though.*
  - *Details discussed in previous contribution to this meeting*
- **The "special" runs became the"standard" operation!**
  - *Required meticulous followup of interlock changes!*
  - *More difficult to have all the teams aware for these rare configurations*
- **Some controls reliability issue must be fixed**

Proposals by Ralph A.

Email by Ralph before the LMC when the incident was discussed

-) There is NO double protection: a jump or drift of the single LVDT position reading (we had this at other times) would have completely screwed us up. In this case the LVDT was right and we were protected. So there is protection based on a SINGLE measurement which is not supposed to be 100% safe.
-) It is abnormal that pots sometimes move, sometimes not. Must be fixed.
-) The RESET procedure either does not do what people think (move to out stops, reinitialize motor to known position) or it clearly failed when we applied it. Pot started moving but stopped 20% of its way, still reinitializing. This caused the problem and messed up the calibration, as you describe.
-) The RESET procedure is not enforced after the override k
enforced before use of RP's.
-) The RESET procedure is not protected against mis-use. We must enforce that a RESET is only done after being authorized by the machine to a particular person (for collimators we do this via the piquet procedure).
-) The whole thing can be easily improved, for example by making a sanity check after RESET (LVDT's versus motors - if more than ~0.3mm difference we should stop).
We must realize that RP's (2 LVDT's for 2 pots) have much less redundancy than collimators (6 LVDT's plus 4 resolvers for 2 jaws). Also, they connect many more pots per PXI than we do for collimators. For these reasons I find it important that we do not compromise on the quality of the RP controls.

And done only if the pot is on the switch!!

Reserve slides

Observations on pot XRPV.A7L1.B2

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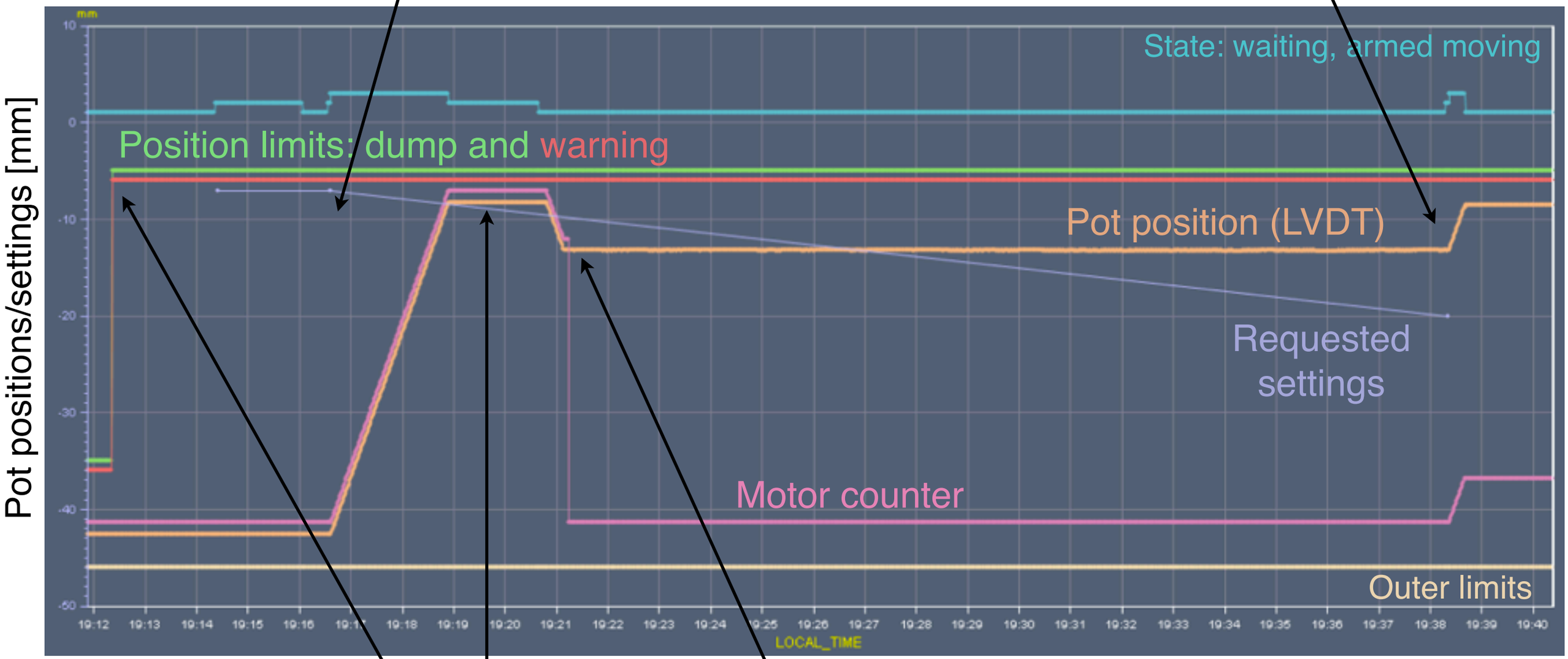


Time [hh:mm]

1. Open limits to physics settings (closest position allowed = 6.5mm > 17σ)

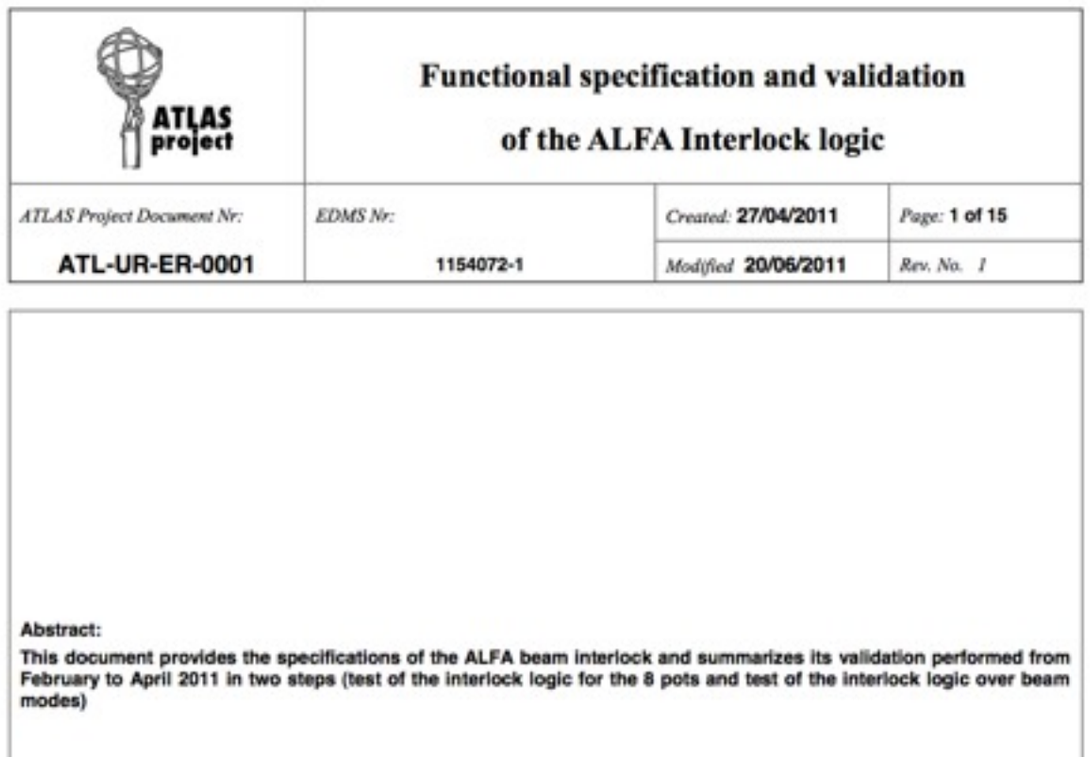
3. Attempt to move out failed

4. Requested RESET with pot in beam: it moves back by 5mm, does not find the switch BUT reset motor counter

If the pot had not been stopped

- Automatic go-home request upon reaching warning limits (without beam dump)
- Beam dump request upon reaching dump limits
- Reminder 1: Interlocking strategy is based on LVDT reading only (“real” jaw position if LVDT not affected by noise).
- Reminder 2: New reset procedure on reference OUT positions added this year to avoid accumulating offsets between LVDT and motors
- Reminder 3: The machine protection functionality of each pot was tested individually

<http://elogbook.cern.ch/eLogbook/eLogbook.jsp?shiftId=1033822>



ATLAS project

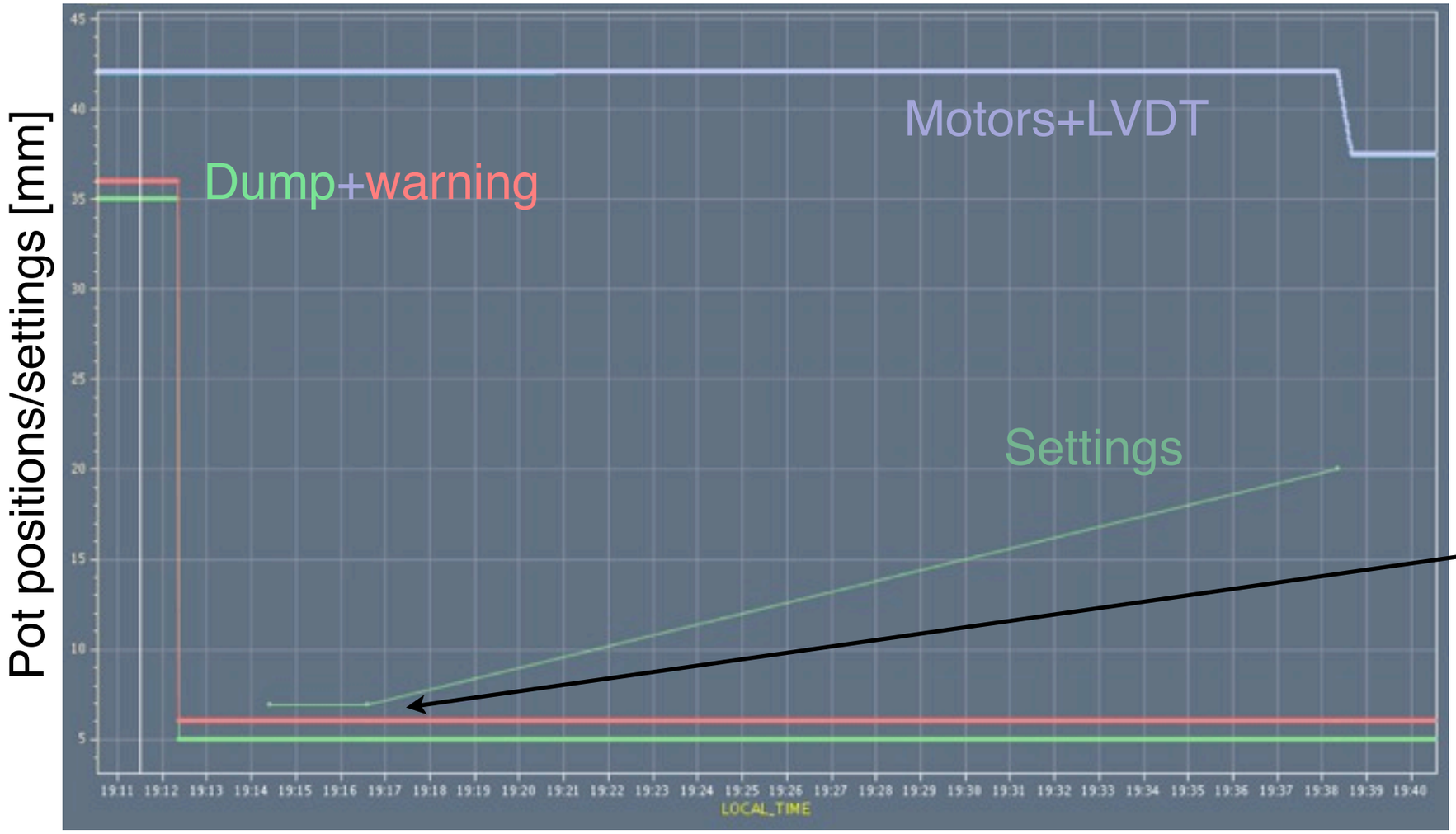
Functional specification and validation of the ALFA Interlock logic

ATLAS Project Document Nr:	EDMS Nr:	Created: 27/04/2011	Page: 1 of 15
ATL-UR-ER-0001	1154072-1	Modified 20/06/2011	Rev. No. 1

Abstract:

This document provides the specifications of the ALFA beam interlock and summarizes its validation performed from February to April 2011 in two steps (test of the interlock logic for the 8 pots and test of the interlock logic over beam modes)

Observations of other pot



Time [hh:mm]

Pot did not move at all at the first request to physics settings. Not affected by problems that appeared later.

Summary of facts

- Pots were moved without having performed the reset procedure.
- Some pots did not move when commands are sent and accepted.
- Reset command launched with pot inside.
- **Low-level reset procedure did not realize that the pot was far from the switch and reset the motor counter nevertheless. This should not be done if the out switch is not active!**
- Movements towards the beam is a consequence of the mismatch between motor counter and pot position.
- In the present condition, the safety of the machine was not compromised because the interlocks were active.
  We can repeat a subset of machine protection tests in case of doubts.