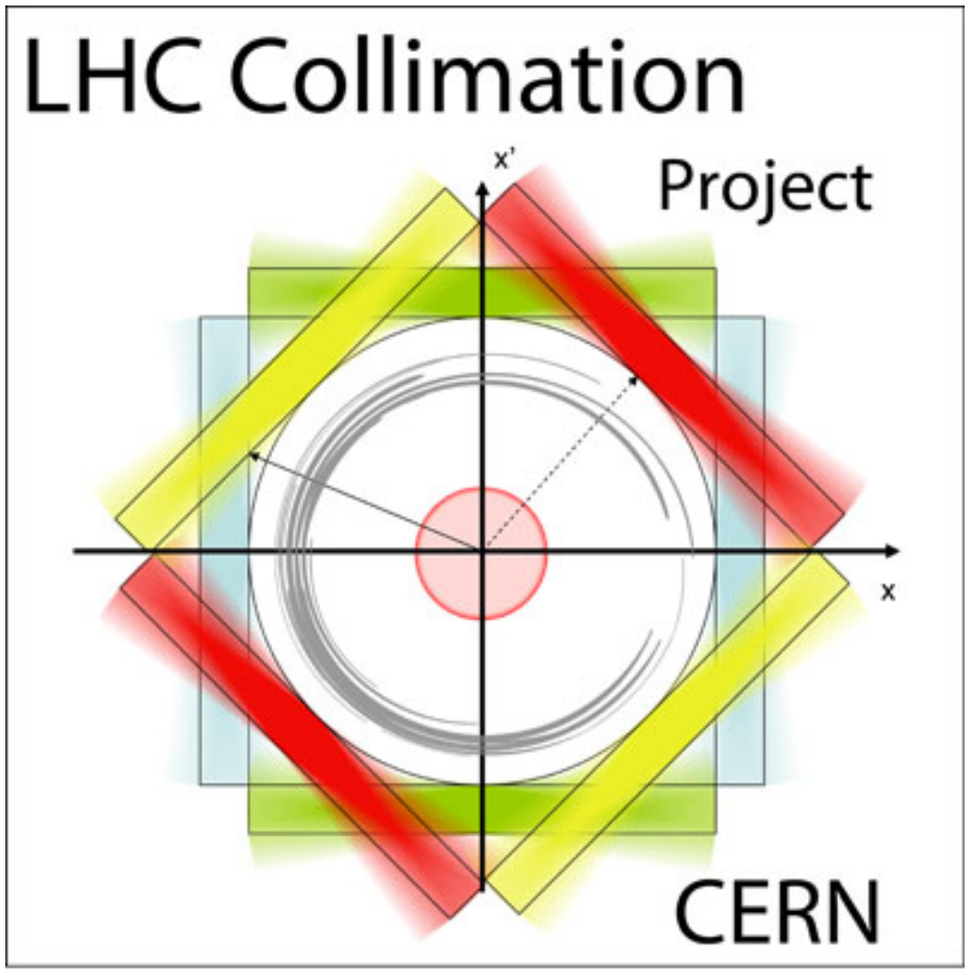
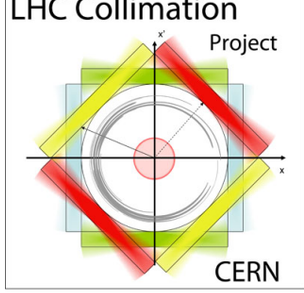
Collimation System



B.Salvachua, R.Bruce, A.Mereghetti, S.Redaelli,
G.Valentino, D.Mirarchi, P.Hermes

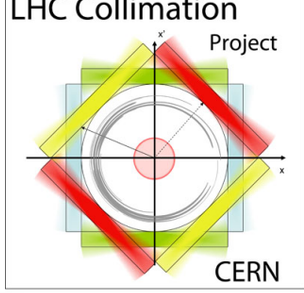
on behalf of the Collimation Team

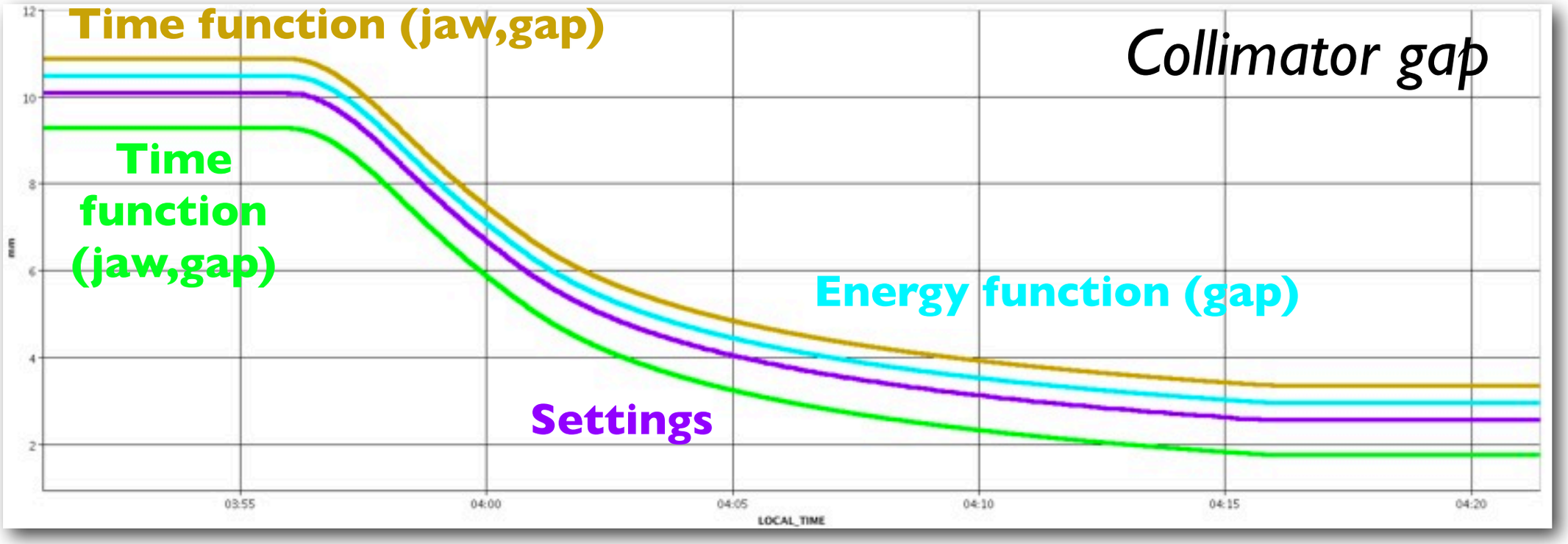
Outline



- **Introduction**
- **Collimators operation:**
  functions, global aperture and final settings
- **Status of MP validation:**
  validation without beam and deployment of operational settings
- **Alignment results**
- **Loss maps validation**
- **Dump “statistics”**

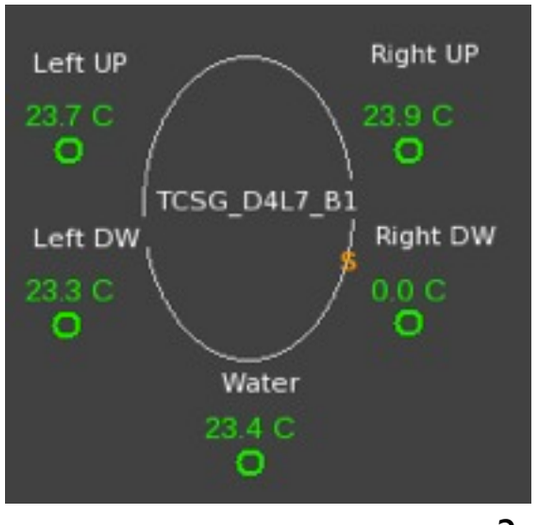
Introduction



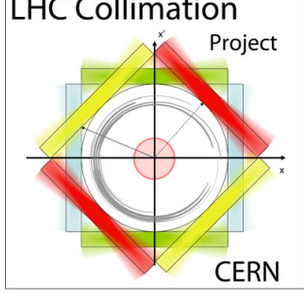


- **POSITION INTERLOCKS**
  - Inner and outer thresholds as function of time for each collimator axis and gap (24 functions)
  - Maximum gap versus energy (2 functions). *Protection during ramp.*
  - Max. and Min. gap versus beta* (4 functions). *Protection during squeeze.*
- **TEMPERATURE INTERLOCKS:**
  - *Interlocked temperature sensors in the collimator jaws and cooling water.*
  - *More than 500 sensors that can trigger an interlock.*

Project change: EN/ICE → EN/STI

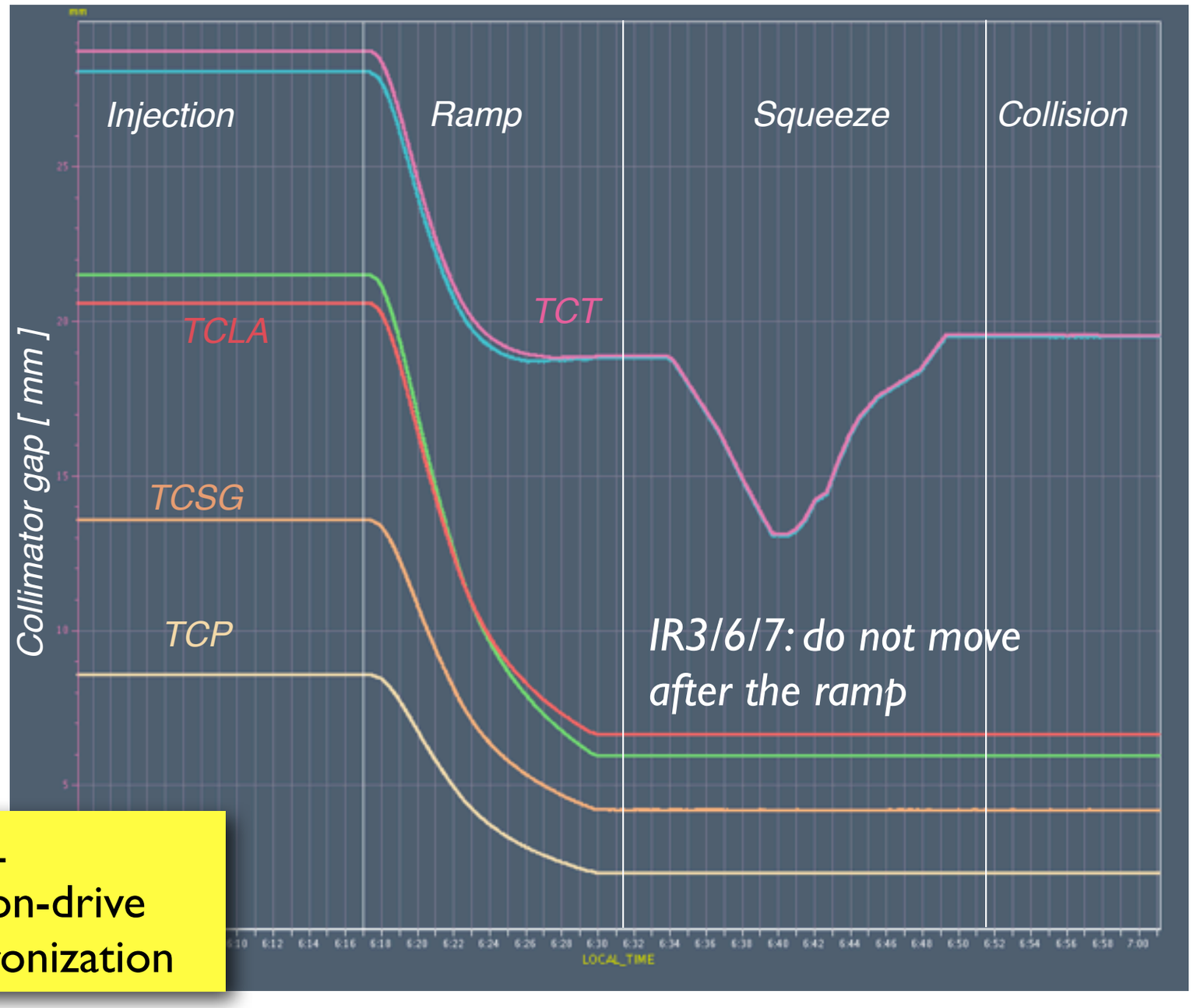


Collimator operation



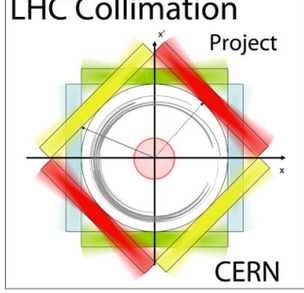
- **Changes in LS1:**
  - 8 additional collimators
  - 18 new collimators with BPMs
  - new absorbers with additional temperature sensors
- **System:**
  - 108 movable collimators
  - 93 ring cleaning

Collimator movement during OP cycle



Collimators needed in ALL operational phases. Function-drive motion and precise synchronization

Global Aperture



- **Aperture is the input for collimator hierarchy, many discussions in collimator settings for Run 2:**
  - 2014 Evian/Chamonix, R.Bruce
  - 19/01/2014 CWG, R.Bruce
  - 20/05/2015 LMC , S.Redaelli
- **LMC endorsement to stay at 80cm beta-star (gives 2σ margin)**
- **Decided to use the 2σ margin as machine protection to tertiary collimators and triplets in low-β* regions**

Assuming a 3.75μm emittance and 11σ long-range beam-beam separation, we get:

TCP7	5.5
TCS7	8.0
TCS6	9.1
TCDQ	9.1
TCT1/5	13.7

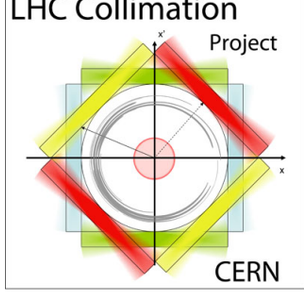
for a protected aperture in IR1/5 of 15.4

Notes:
- TCT IR2: 26 (β* = 10 m)
- TCT IR8: 15 (β* = 3 m)
- TCDQ down to TCS6 level,

R.Bruce et al.

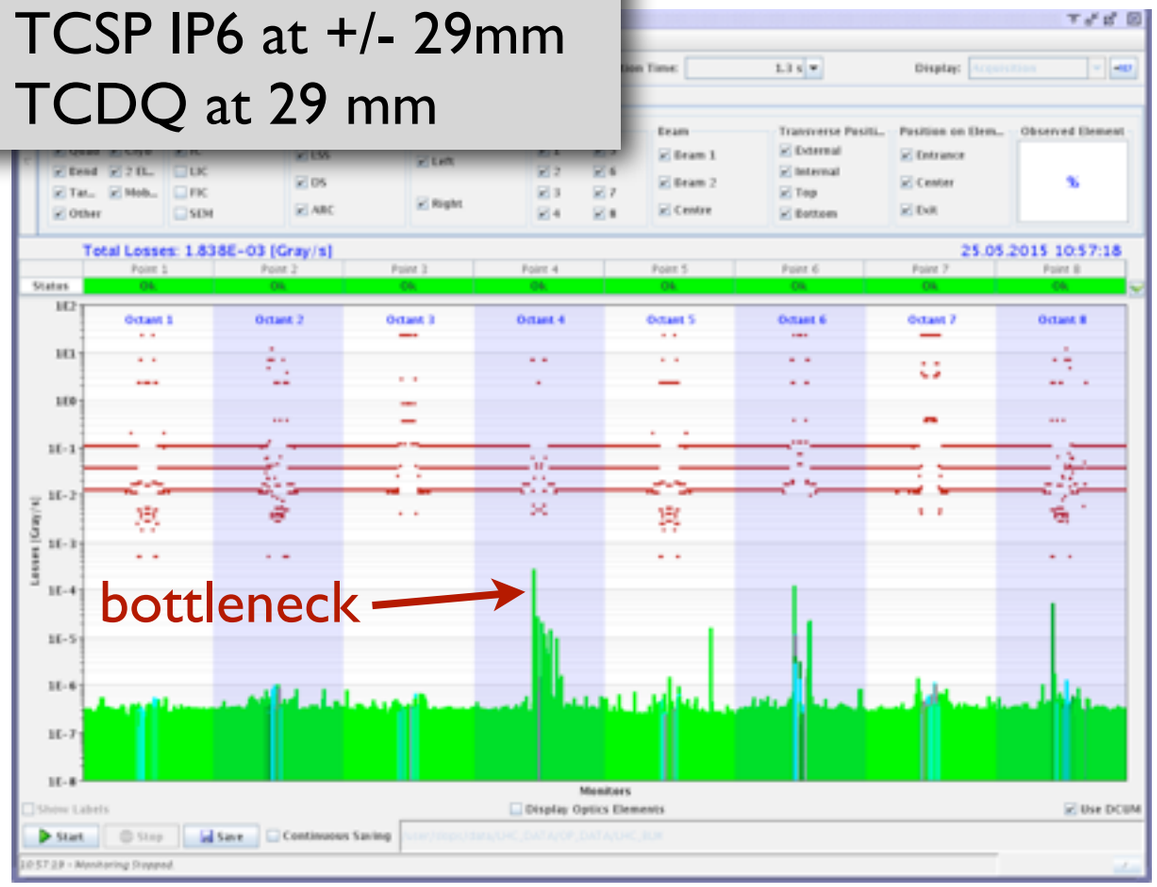
What is the aperture at 6.5TeV - 80cm?

Global Aperture Measurement

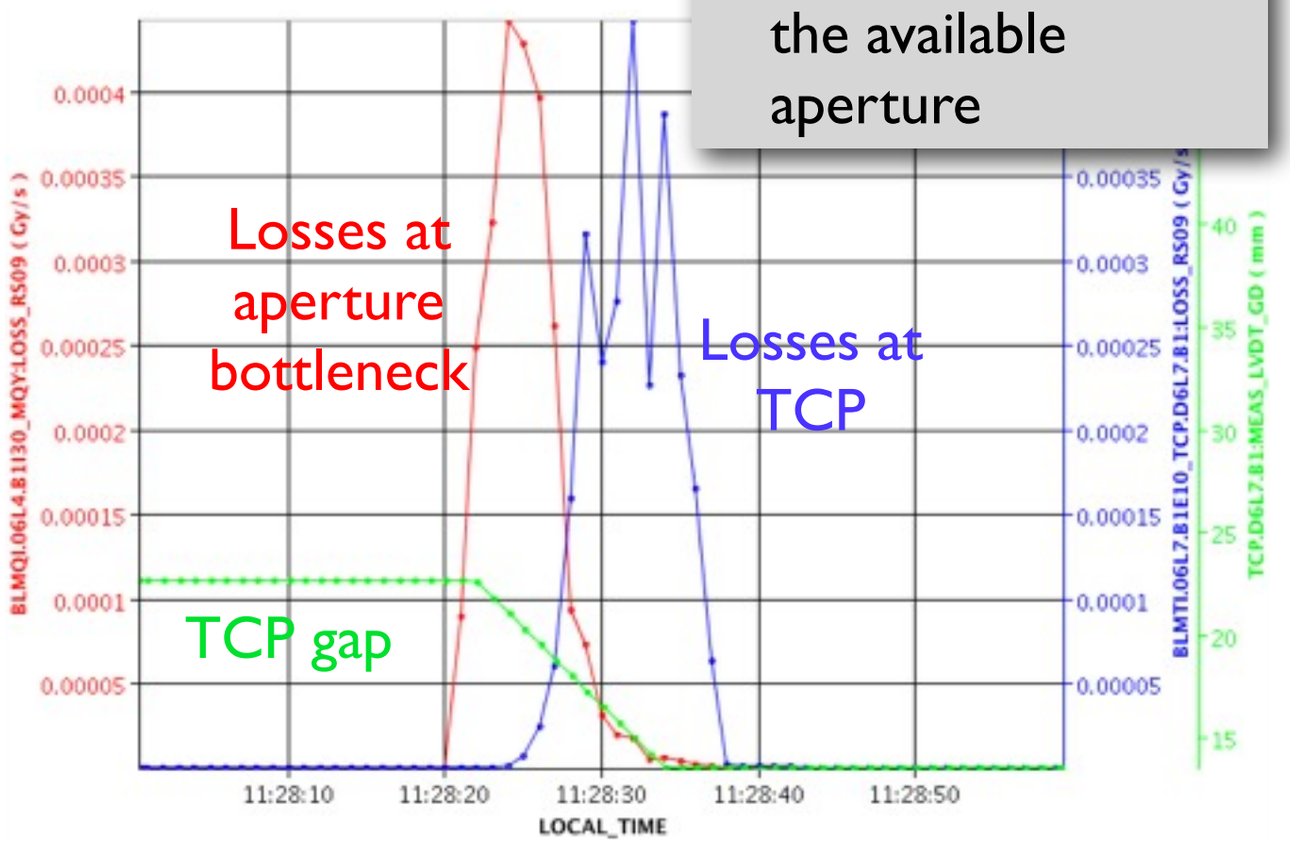


- **The techniques:**
  - Retract all collimators and identify bottleneck.
  - Collimator scan: while exciting the beam with ADT move in/out bottleneck collimators (TCP at injection or TCT at squeeze/colliding).
  - Local bump: match a bump with the identified bottleneck and touch aperture after defining beam size with primary collimators.

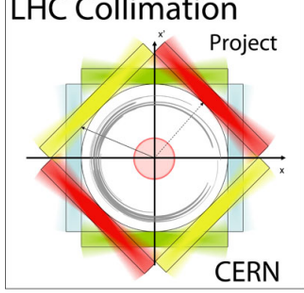
Retracting collimators:
TCP IP7 at +/-25mm
TCSP IP6 at +/- 29mm
TCDQ at 29 mm



Then Collimator scan to determine the available aperture



2015 settings strategy



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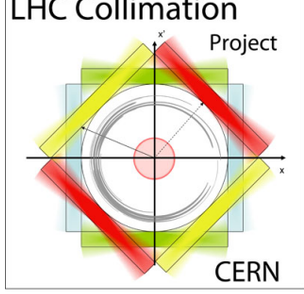

- **Preliminary analysis of the aperture confirms assumptions to calculate margins and beta-star reach.**

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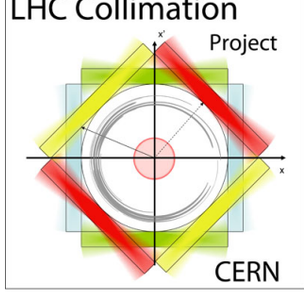

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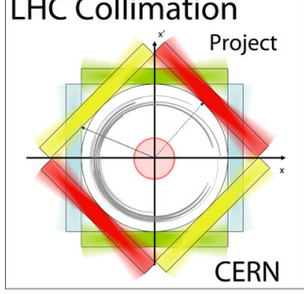
*6.5TeV at 80cm β**

assumed 15.4σ

Plane	Aperture [σ]	Bottleneck
B1H	17.2-18.2	IR5
B1V	15.7-16.2	IR1
B2H	16.2-16.7	IR1
B2V	15.7-16.2	IR1

Pascal D.Hermes

2015 settings strategy



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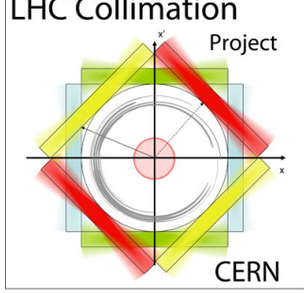
2015 Collimator Settings

		450 GeV	6500TeV
IP7	TCP/TCSG/TCLA	**5.6/6.7/10**	**5.5/8.0/14.0**
IP3	TCP/TCSG/TCLA	**8.0/9.3/12.0**	**15.0/18.0/20.0**
IP6	TCSG/TCDQ	**7.5/8.0**	**9.1/9.1**
IP1 and IP5	TCTP	**13.0**	**13.7**
IP2	TCTP	**13.0**	**37.0**
IP8	TCTP	**13.0**	**15.0**
IP1 and IP5	TCL4/TCL5/TCL6	**out/out/out**	**15.0/15.0/out**

Status MP validation



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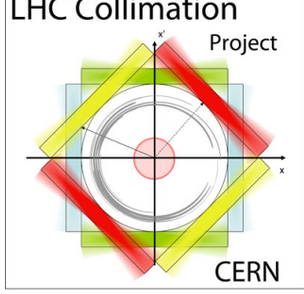

- **Functionality of position interlocks:**
  - see also talk on 27/03/2015 MPP, G.Valentino
  - Executed 93 x 18 = 1674 sequences in a couple of days, found few issues in BIC connections that were quickly solved.
  - Tests are now in Acc.Testing as sign-only, plan for full functionality in 2016.

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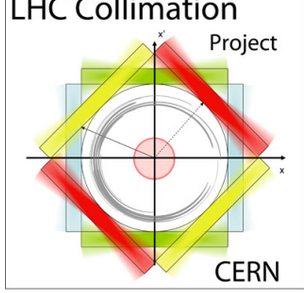

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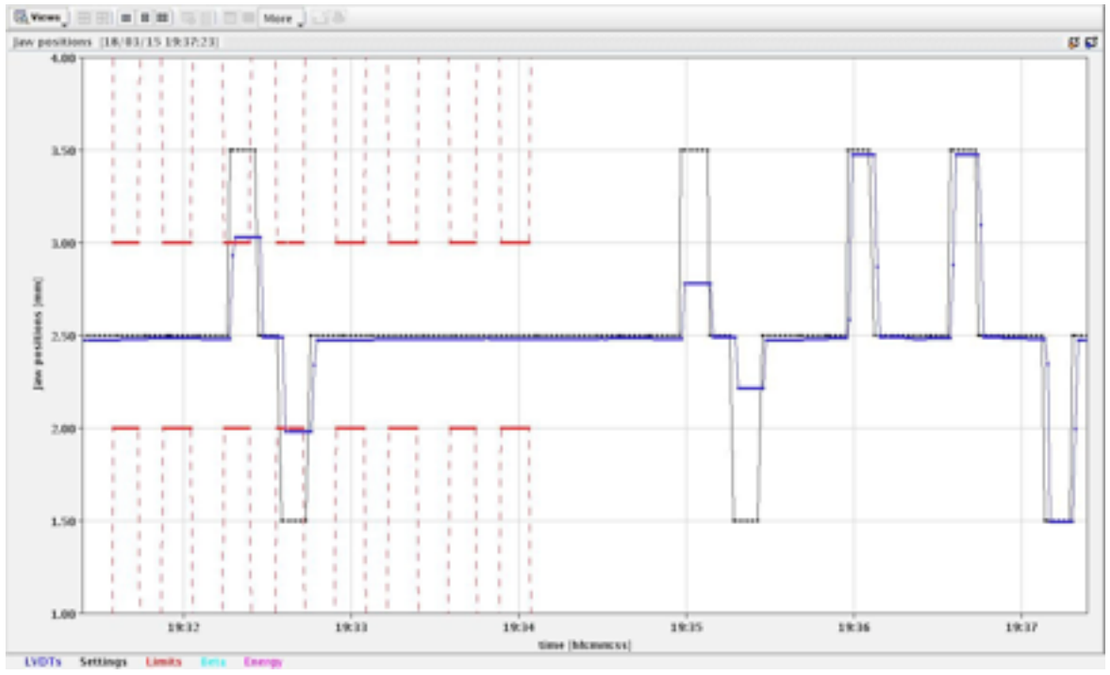
  - during commissioning RBAC roles distributed in a more relaxed manner, is there a common procedure for RBAC lists?



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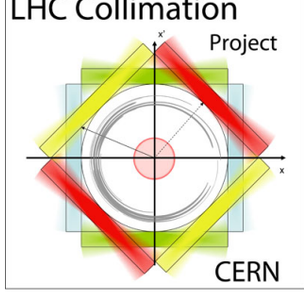

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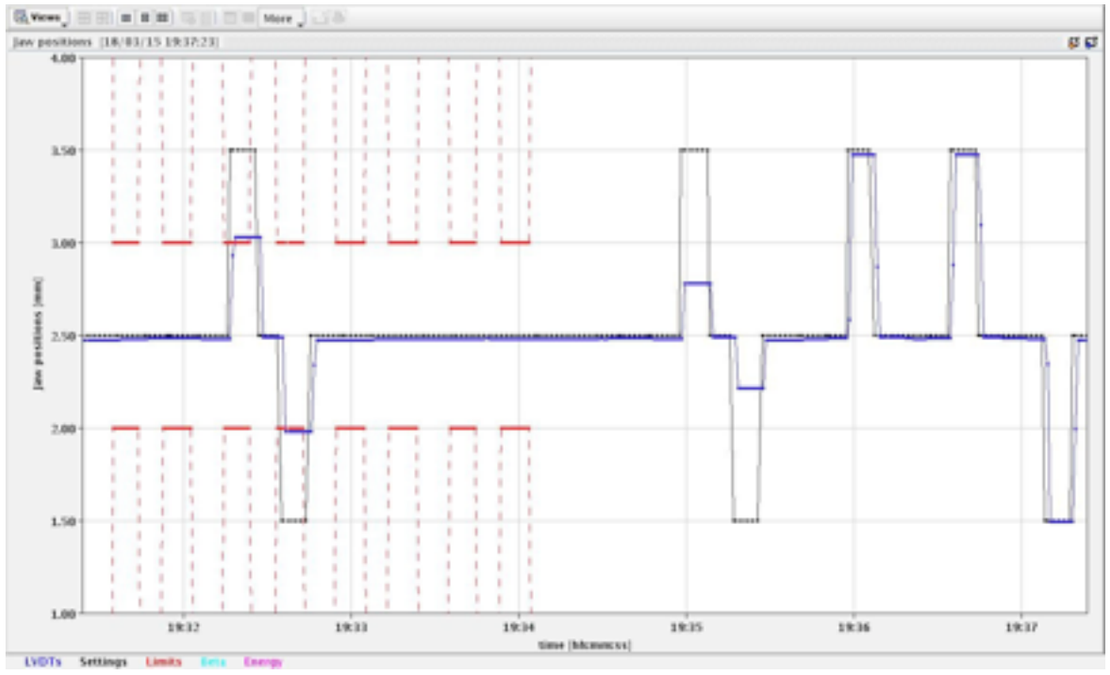

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  - also checked few sensors disabled

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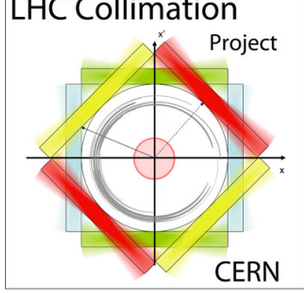

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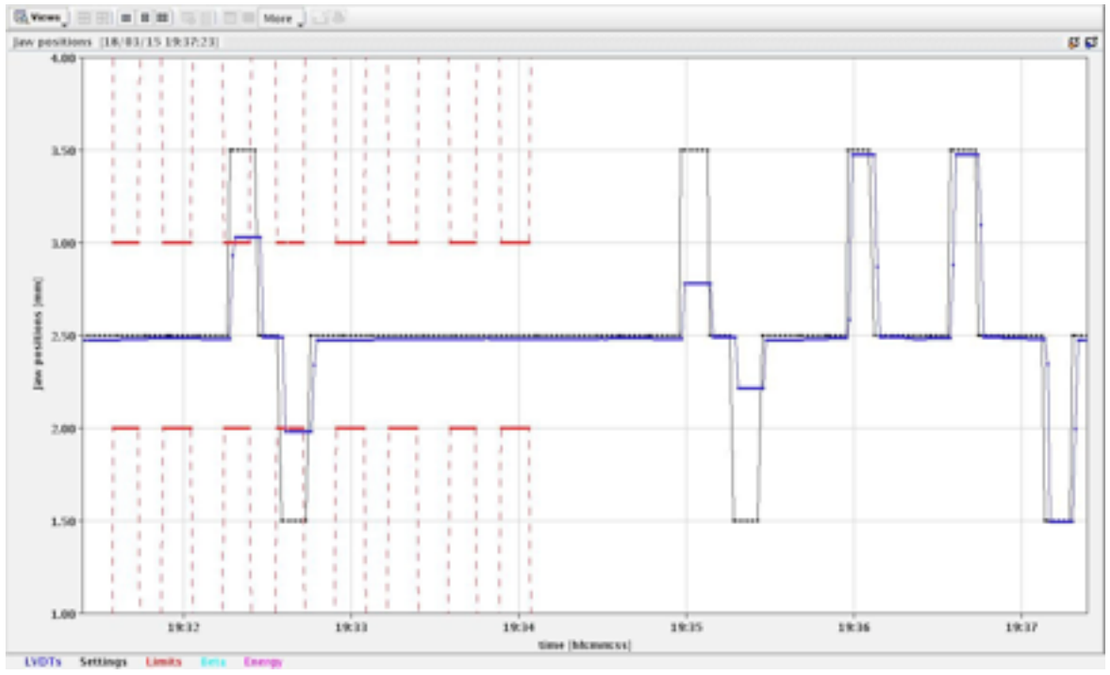

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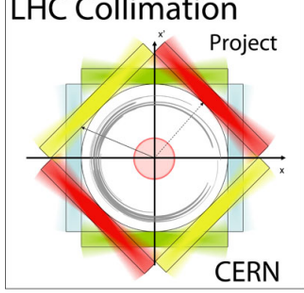

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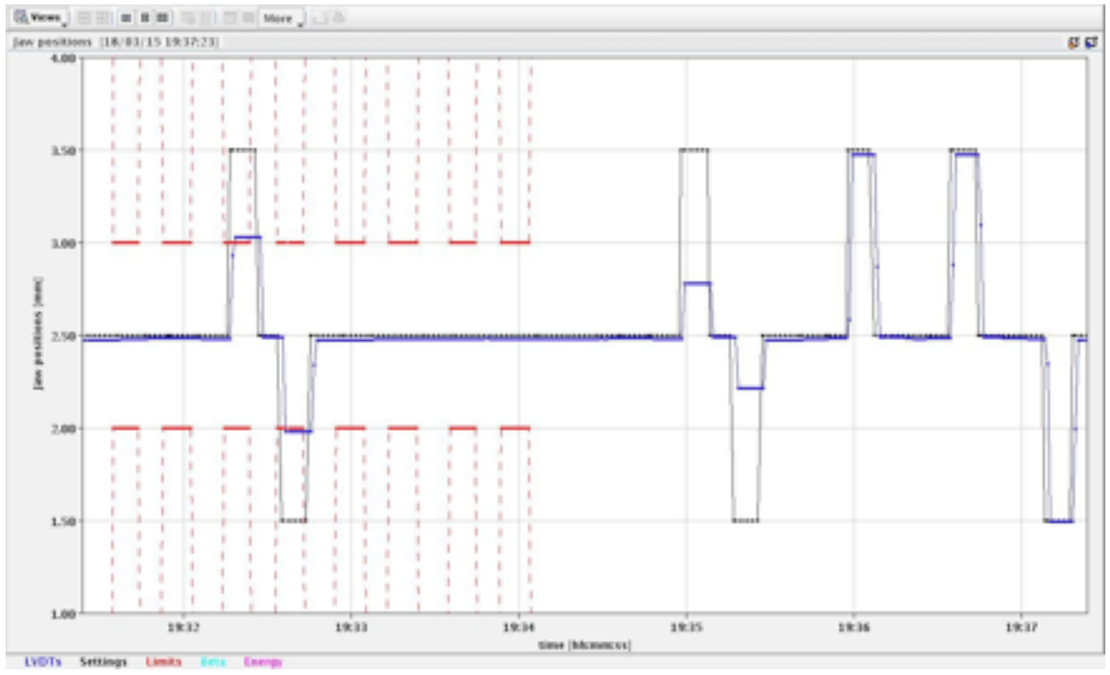

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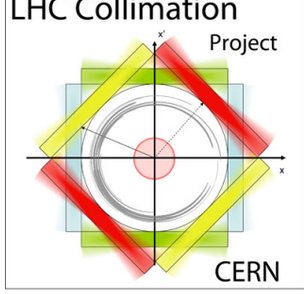
Activities started in summer 2014 in order to be ready for start-up

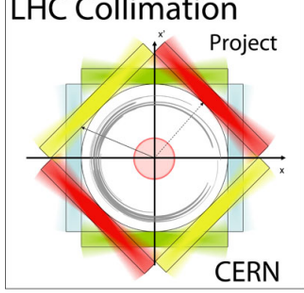
Status deployment Operation



- **We have deployed final collimator settings, with tight positions limits and energy depending limits. To be done in the next days the deployment of beta-star (wait to finish with the de-squeeze). Limits ready for the 48 bunches.**
- **Strategy for commissioning:**
  - Coarse settings for pilot ramps (4 collimators/beam ramped) TCSP6/TCP3/TCP7(H/V) 20/30/25σ
  - Less coarse settings for nominal ramps (4 collimators/beam ramped, collimators aligned) 10/15/20σ
  - Final ramp functions (all collimators ramped and aligned)
  - Nominal squeeze/colliding vs special runs:
    - Flat orbit vs Crossing angle settings of the TCTs
    - Squeeze vs de-squeeze

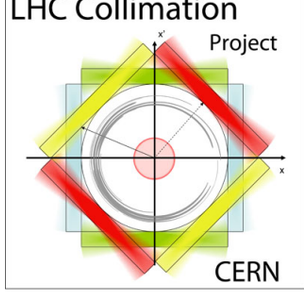
Many OP configurations are already deployed

Collimator Alignment



G.Valentino

Collimator Alignment



All collimators aligned all cycles.

Alignment tool reduced more the time spent in alignment (max. 80 collimators around 3 hours)

New alignment tool to check centers in LSA vs alignment result. This was an action from the MPP workshop in 2013

G. Valentino

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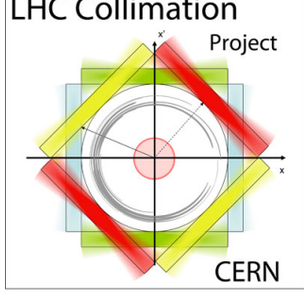

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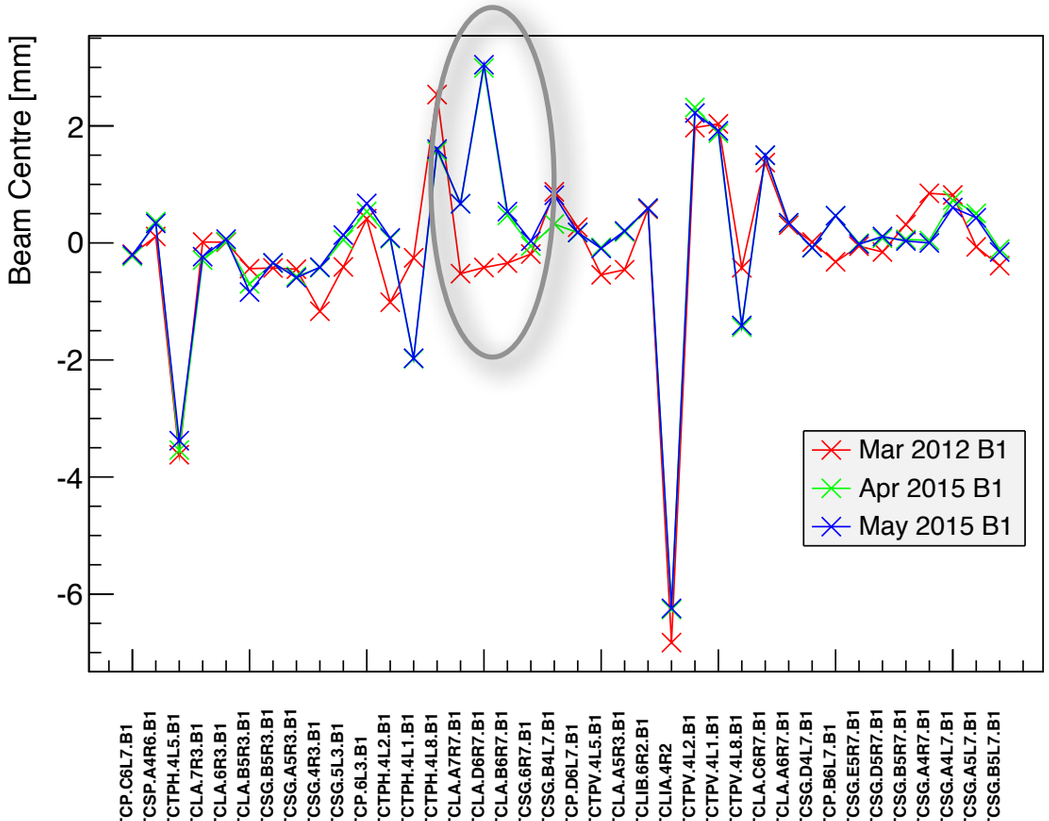
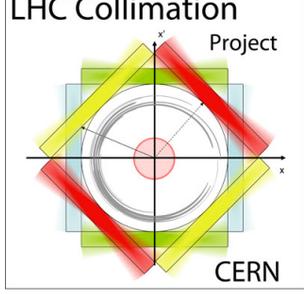
Large offset found on TCLA.D6R7.B1.

- *15mrad tilt observed in LS1*
- *Corrected but re-measured in May and was 16mrad*
- *Will be corrected in TS1 and will need to be re-aligned*

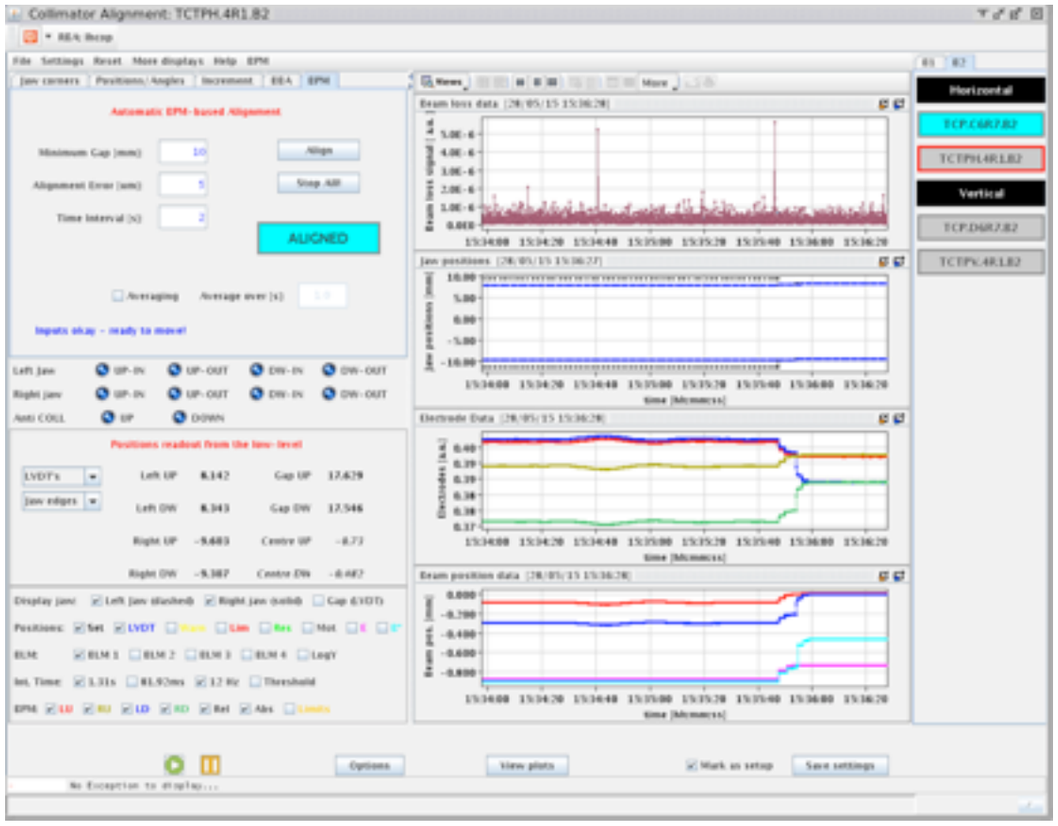


G. Valentino

BPM Collimator Alignment



- First alignment tests at top energy with BPMs were also done (in IR1 only). The alignment takes few seconds.
- Centers compatible with Beam Based Alignment (comparison done without correction of electronic gains etc.)
- Very promising results, however BPM DOROS electronics to populate the rest of IRs are not yet available. It was foreseen to have them installed during TS1 but the last news from BI were not encouraging.



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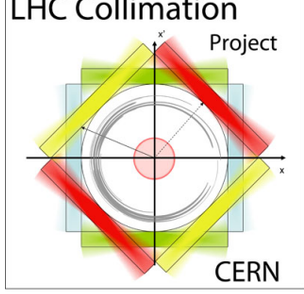

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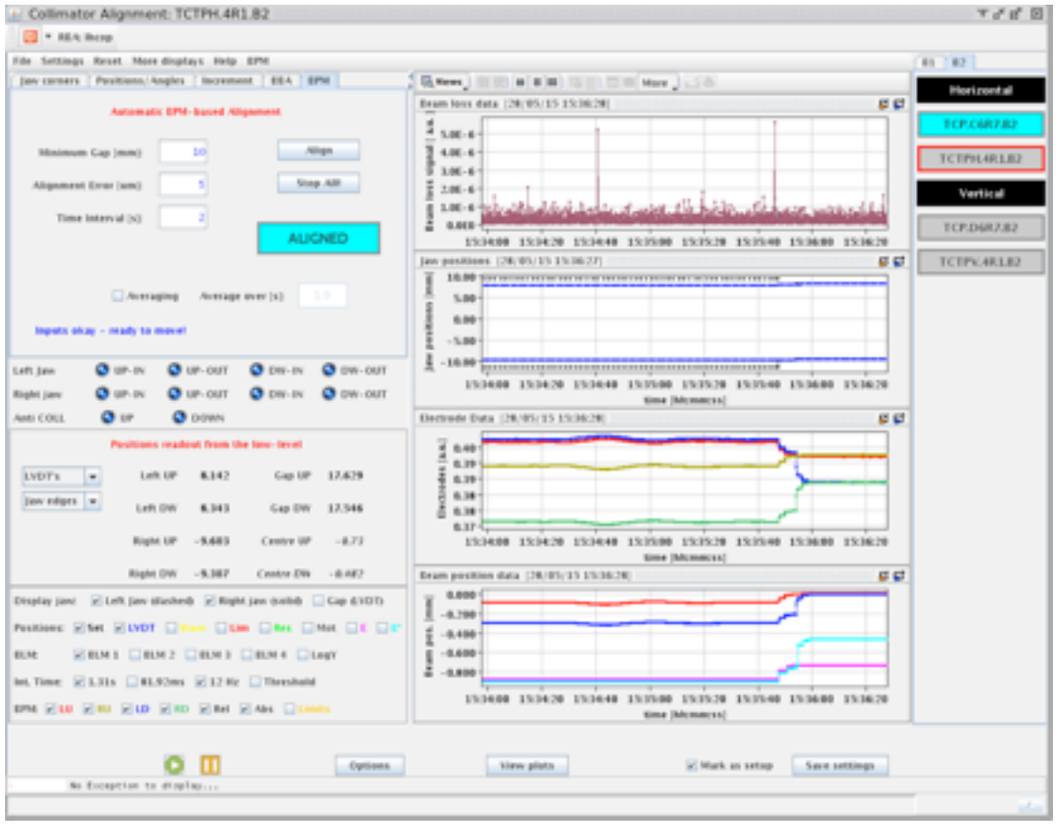
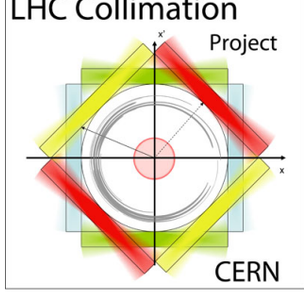


First comparison Squeeze beams

(mm)	BBA	BPM UP	BPM DW	MAD-x
TCTPH.4L1.B1	-0.503	-0.772	-0.367	-0.5275
TCTPH.4R1.B2	-0.843	-1.185	-0.905	-0.865
TCTPV.4L1.B1	1.143	1.050	1.575	1.235
TCTPV.4R1.B2	1.057	1.065	1.175	0.9575

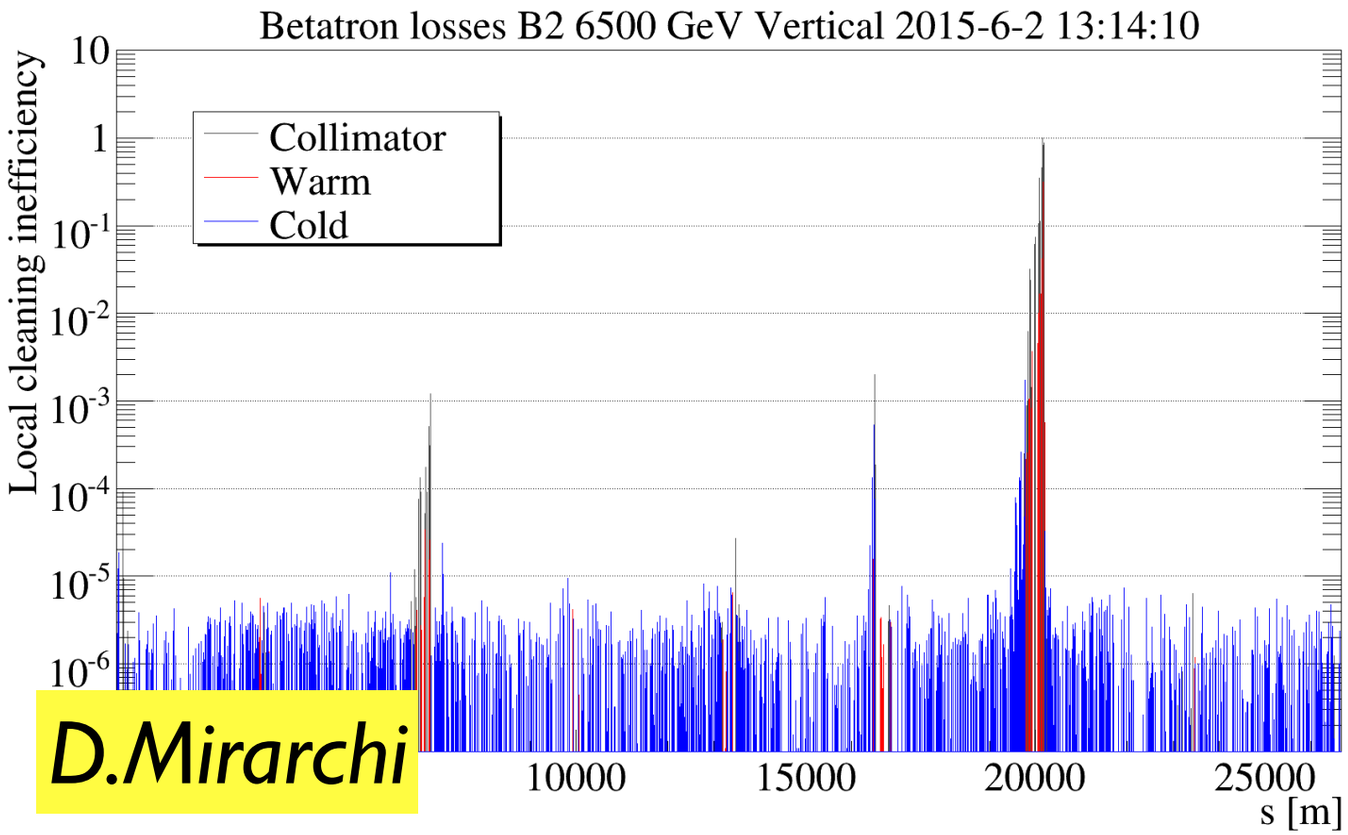
Validation with beam

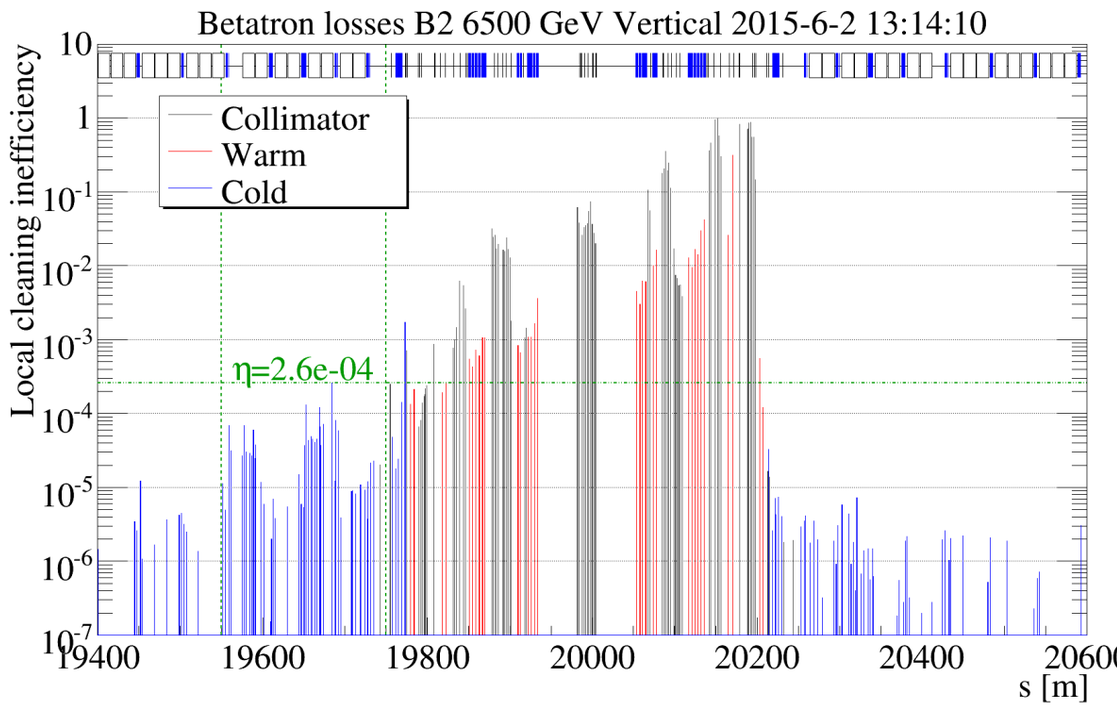


- **Collimation hierarchy and cleaning performance is validated through the analysis of loss maps. Minimum validation for start-up:**

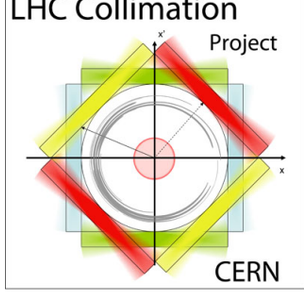
INJECTION Inj. Prot. IN	B1- H	B1 -V	B2-H	B2-V	+500Hz	-500Hz
INJECTION Inj. Prot. OUT	B1- H	B1 -V	B2-H	B2-V	+500Hz	-500Hz
Flat Top	B1- H	B1 -V	B2-H	B2-V	+500Hz	-500Hz
End Squeeze	B1- H	B1 -V	B2-H	B2-V	+500Hz	-500Hz
Colliding all IRs	B1- H	B1 -V	B2-H	B2-V	+500Hz	-500Hz

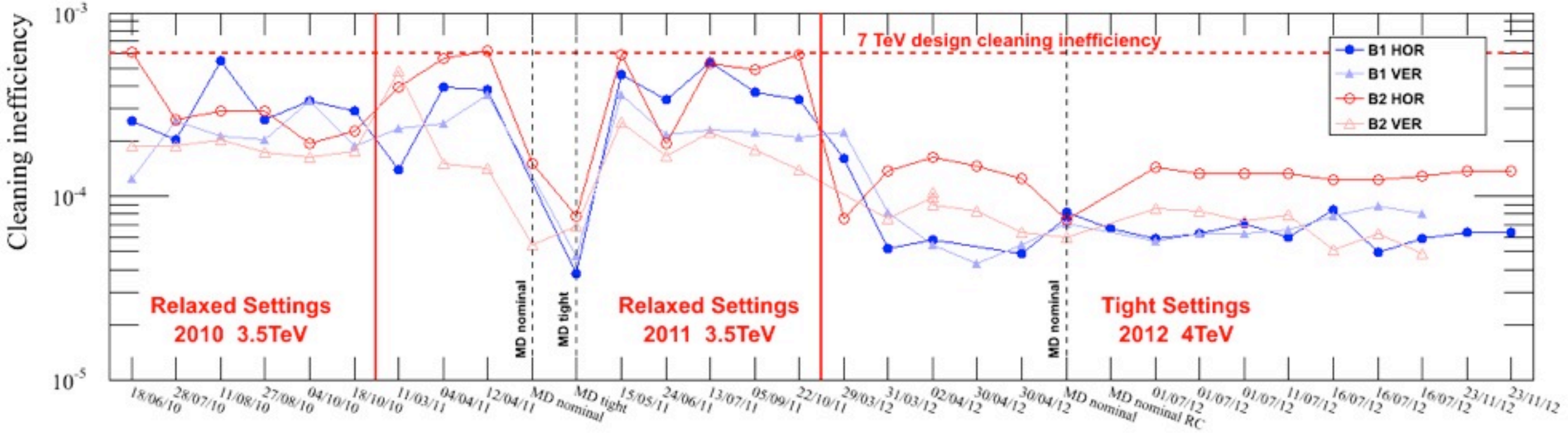
← *done with gentle loss maps technique*





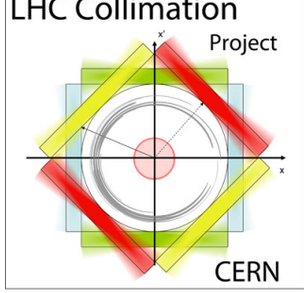
Collimation cleaning

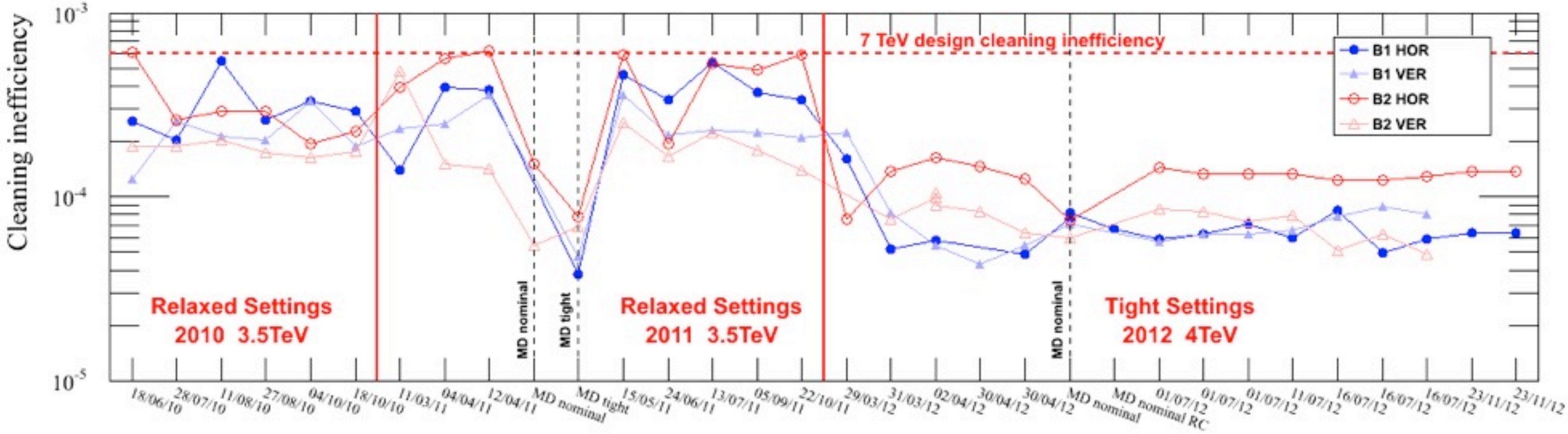


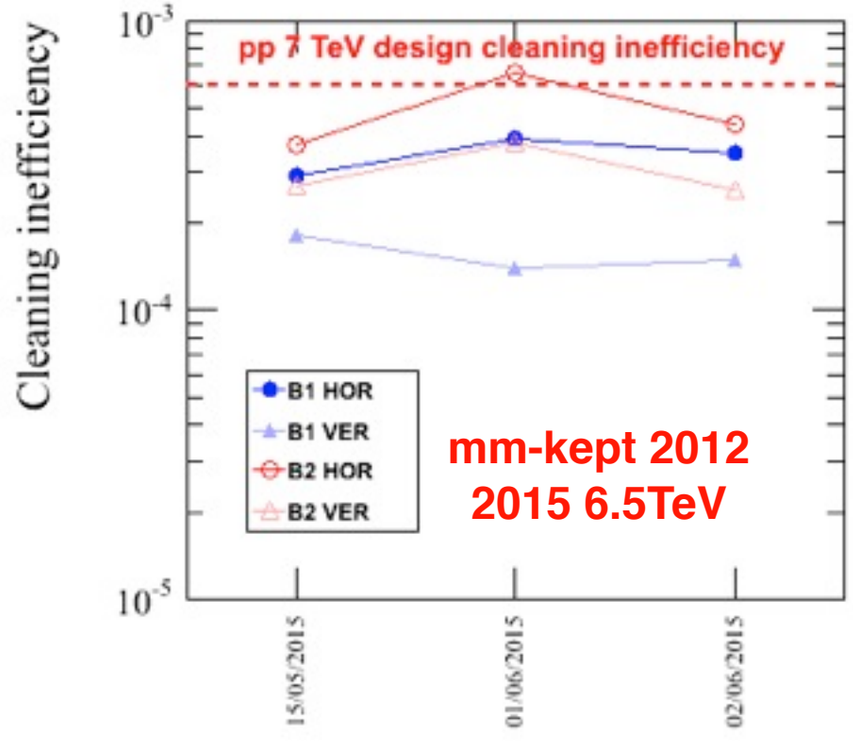


Stability of collimation cleaning during Run 1

Collimation cleaning



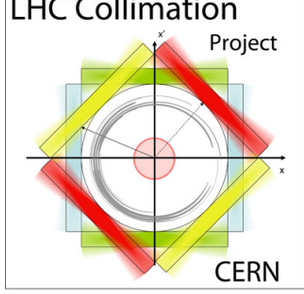




Stability of collimation cleaning during Run 1

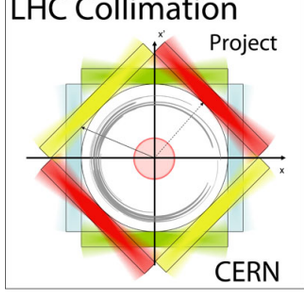
No surprises on the 1st measurement of cleaning in 2015.
Machine stability and reproducibility will be shown in the next months

New techniques for loss maps



- **Betatron loss maps are done with the ADT transverse damper** *(H/V and both beams are done in the same fill, even different beam modes)*
- **However, off-momentum loss maps require 1 fill per side (+/-500Hz RF freq shift)**
- **New techniques in collaboration with RF** ***(Ph. Baudrenghien, M.Jaussi, H.Timko)*** **are being explored. Three paths that could be combined are being explored:**
  - blow-up the bunches longitudinally before doing the loss map so that a smaller frequency shift can be done.
  - add an RF noise so that you push the particles from the core to the off-momentum.
  - feedback based on BLM signals to control of the optimal frequency is being prepared.

New techniques for loss maps



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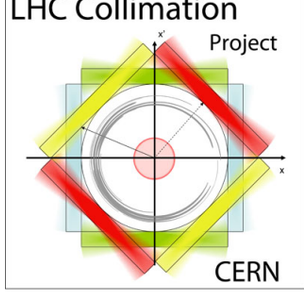
This was partially tested at 450GeV and at 6.5TeV recently. We managed to do 6 off-momentum loss maps in 1 fill but we need a bit more beam time to develop this technique which will later safe time in validation.

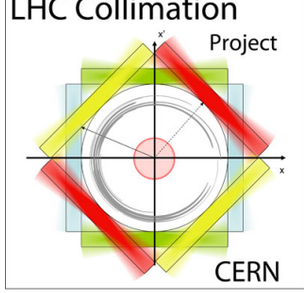
Dump “statistics”



	Injection	6.5TeV
Temperature sensors*	1	
LVDT false reading	1	1

* 1 additional dump at injection during alignment

Temperature Sensors



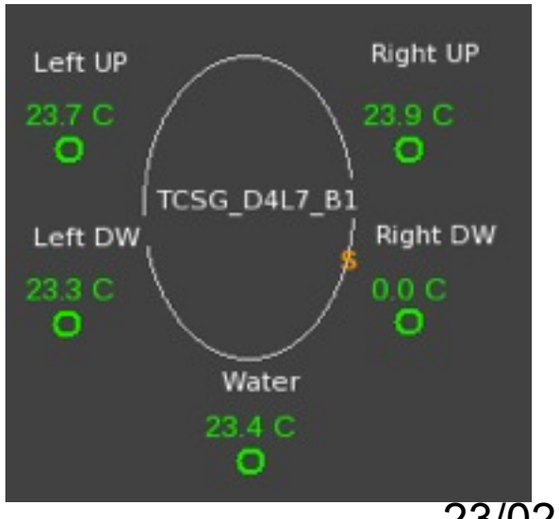
- 1 dump at Injection on false reading of collimator jaw temperature while collimator is moving (spurious false contact)

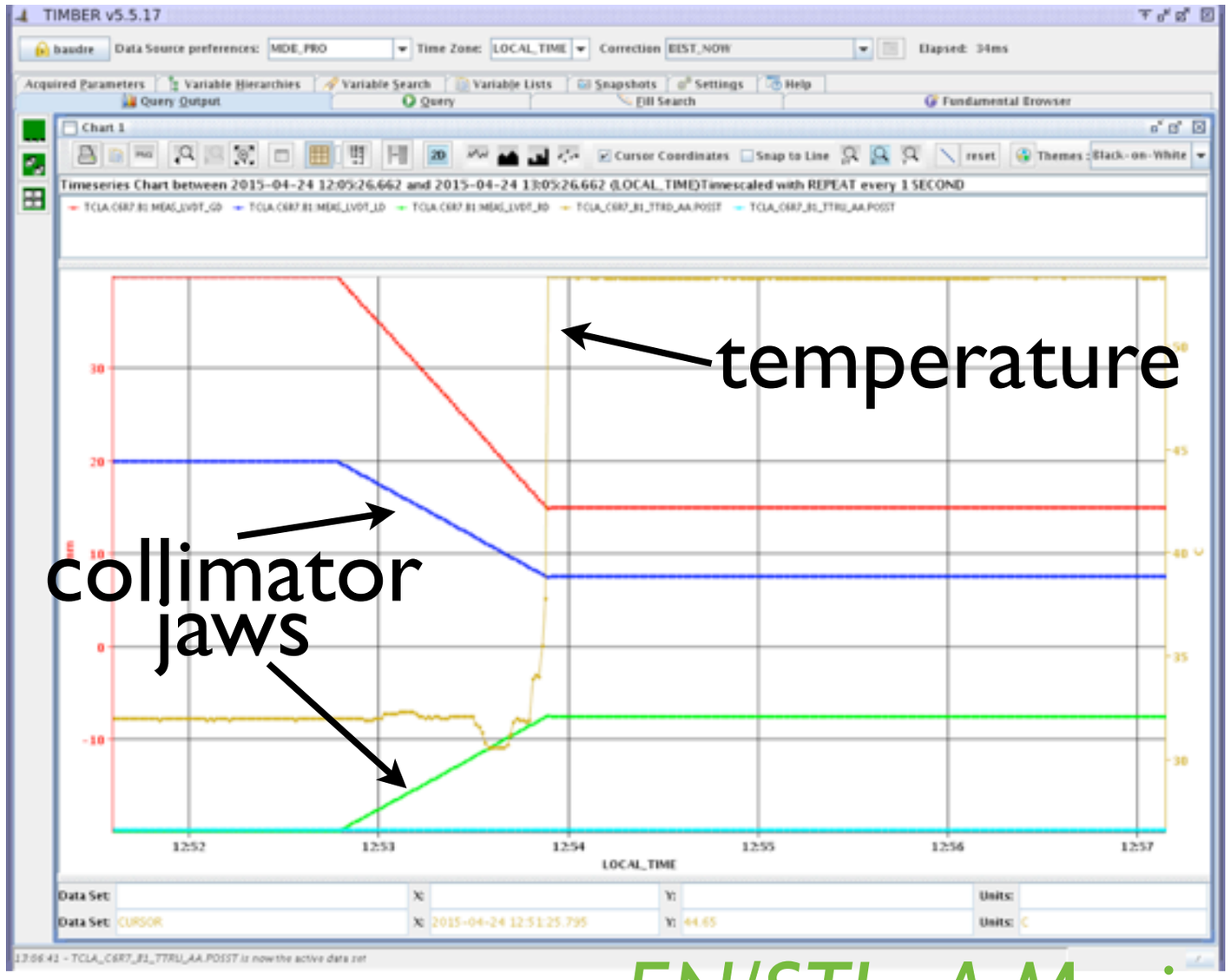
- All temperature interlock reading and logging were tested as part as Machine Protection

- It cannot be repaired but an new interlock logic could be set in place to check both jaw sensors (upstream and downstream) before triggering an interlock.

8/93 collimators

still full monitoring of temperature due to redundancy of sensors





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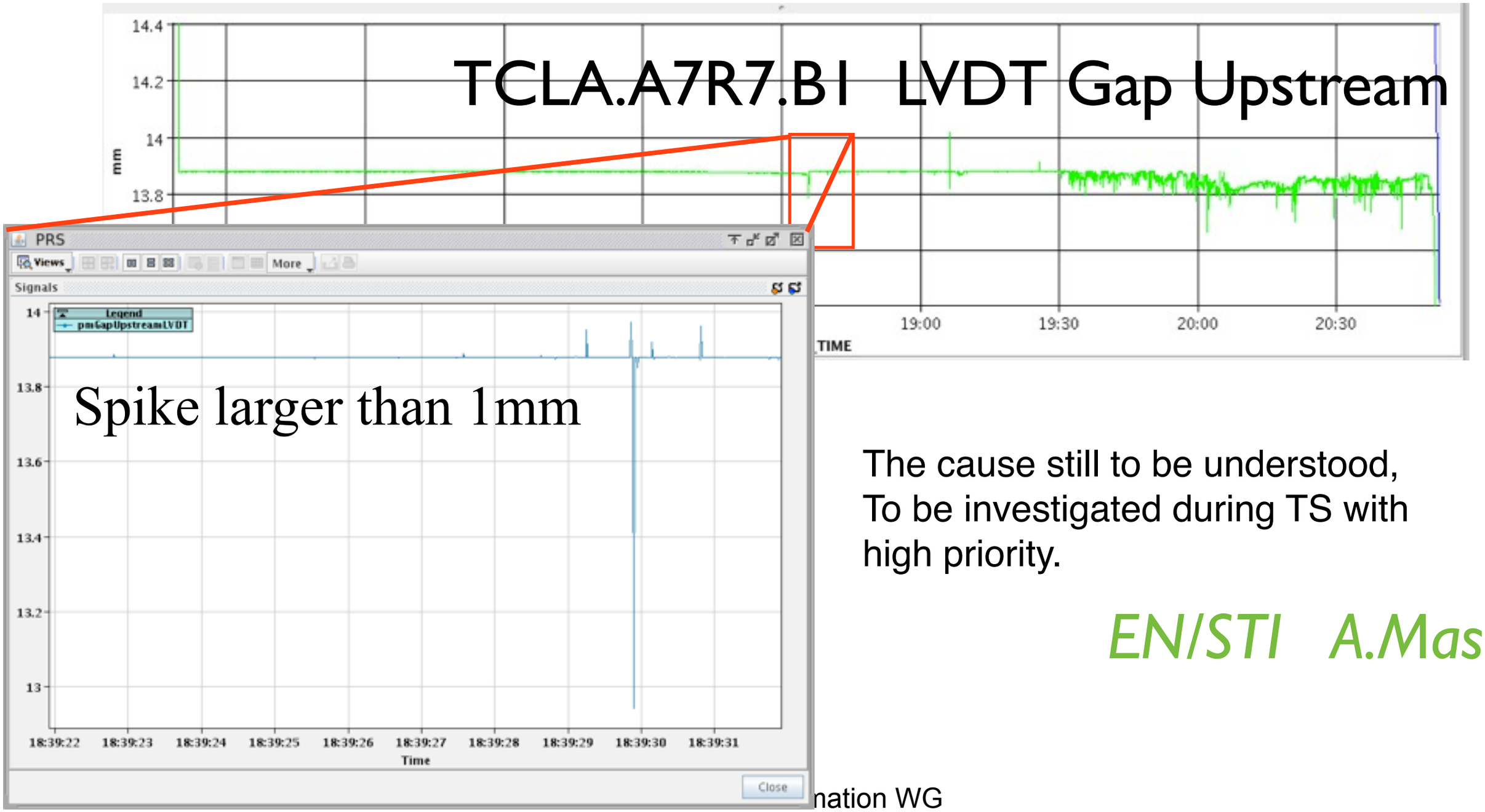
LVDT dump

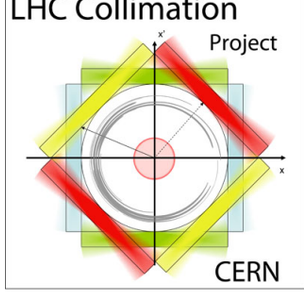
- **1 dump at injection and 1 at top energy (10-11June)**



The cause still to be understood,
To be investigated during TS with high priority.

EN/STI A.Masi

Summary



- **Interlock status: in good shape, only the beta-star are missing and will be deployed in the next days before 48 bunches injection.**
- **Aperture at 80cm β* was measured, the preliminary analysis shows agreement with expected aperture (~15.4σ).**
- **Collimator settings for 2015 defined, deployed and validated.** *Beam time is needed to develop the new technique for off-momentum loss maps, this time will be recuperated if the procedure is well established.*
- **System is ready for intensity steps.**