Performance of the Collimation System during 2015

Evian Workshop on LHC Beam Operation

December 16th, 2015

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thanks also to:

*G. Baud, A. Danisi, M. Donze, J. F. Fuchs, M. Gasior, A. Masi, D. Missiaen,
J. Olexa, J. Wenninger*

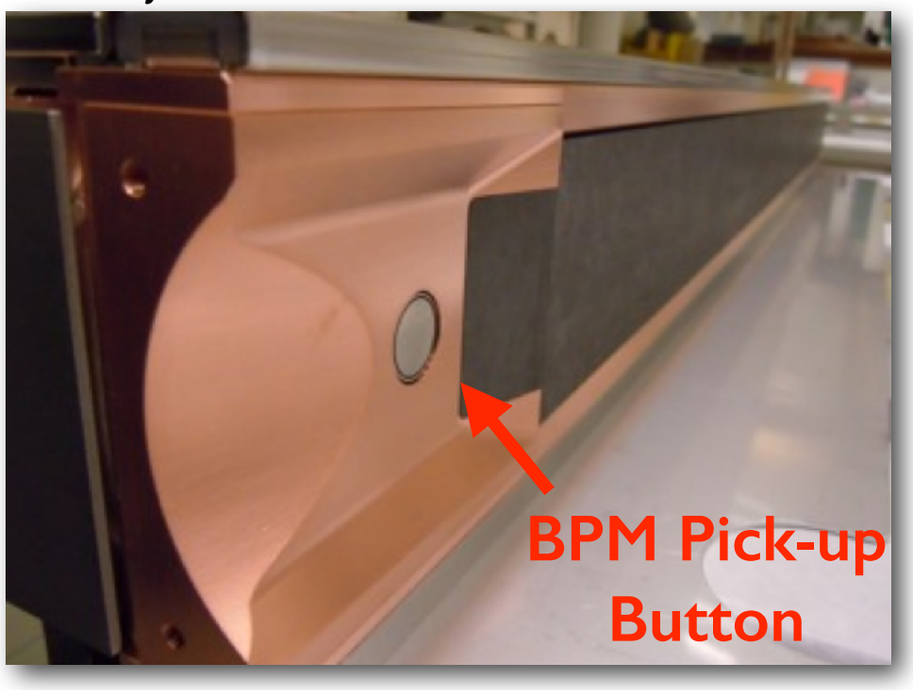
Outline

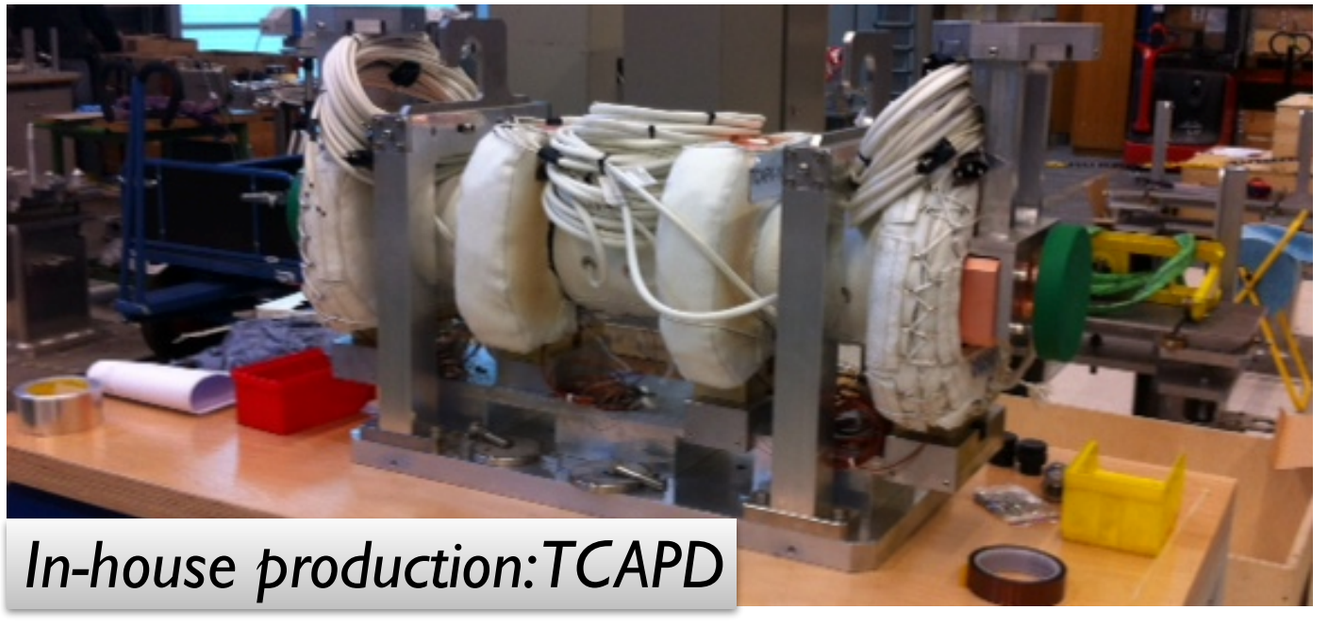
- **Recap: LS1 changes**
- **System commissioning**
  - HW & beam commissioning
- **System performance**
  - Collimation cleaning
  - Issues encountered during the year
- **Embedded BPM collimators**
- **Commissioning plans for 2016**
- **Conclusions**

Recap: LS1 changes

- **Important collimation upgrade program with 30% of the system changed.**
  - New collimators with embedded BPMs (IR1, IR2, IR5, IR8 and IR6).
  - Improved TCL layouts in IR1 and IR5.
  - Installation of additional passive absorbers in IR3.
  - Improved IR8 layout: replacement of 2-in-1 beam collimators by single-beam collimators.
  - Removal and re-installation of 3 primary collimators in IR7 due to ventilation work, and replacement of 1 primary collimator IR7 due to heating problems.

TCSP jaw





In-house production:TCAPD

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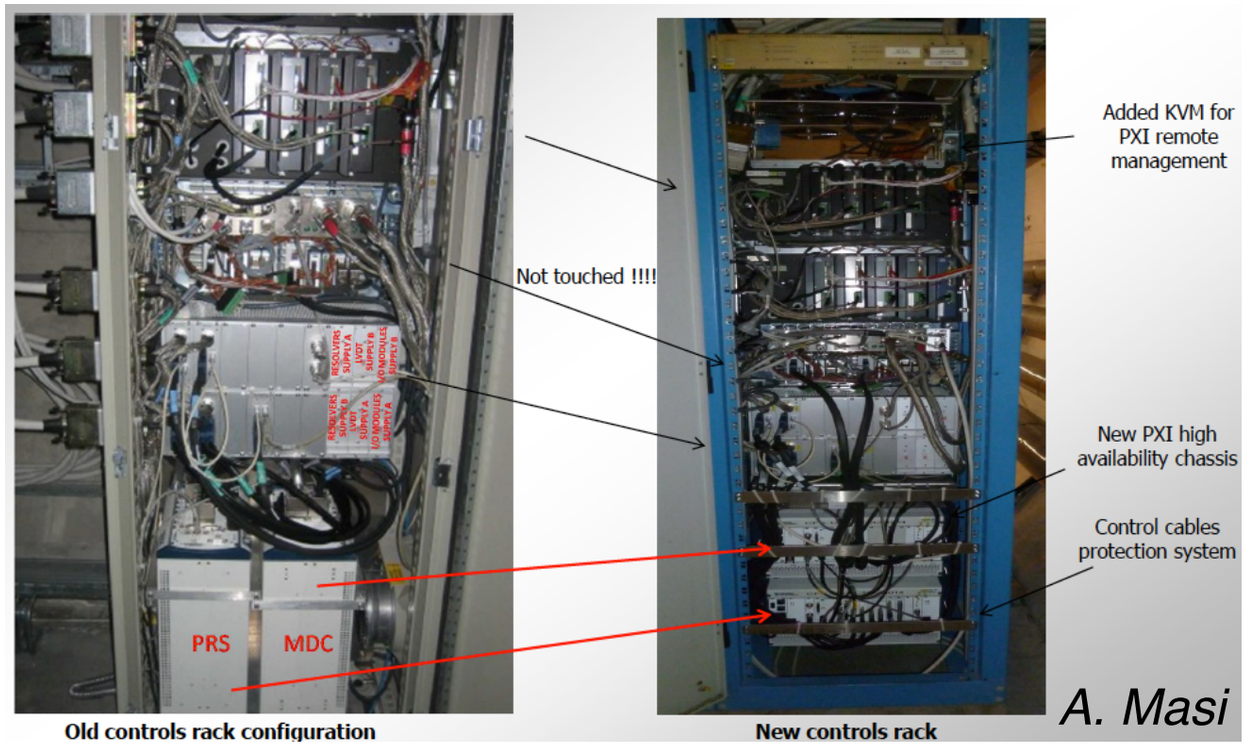
  - Upgrade of rack configuration, improved monitoring + middleware controls upgrade to FESA3.



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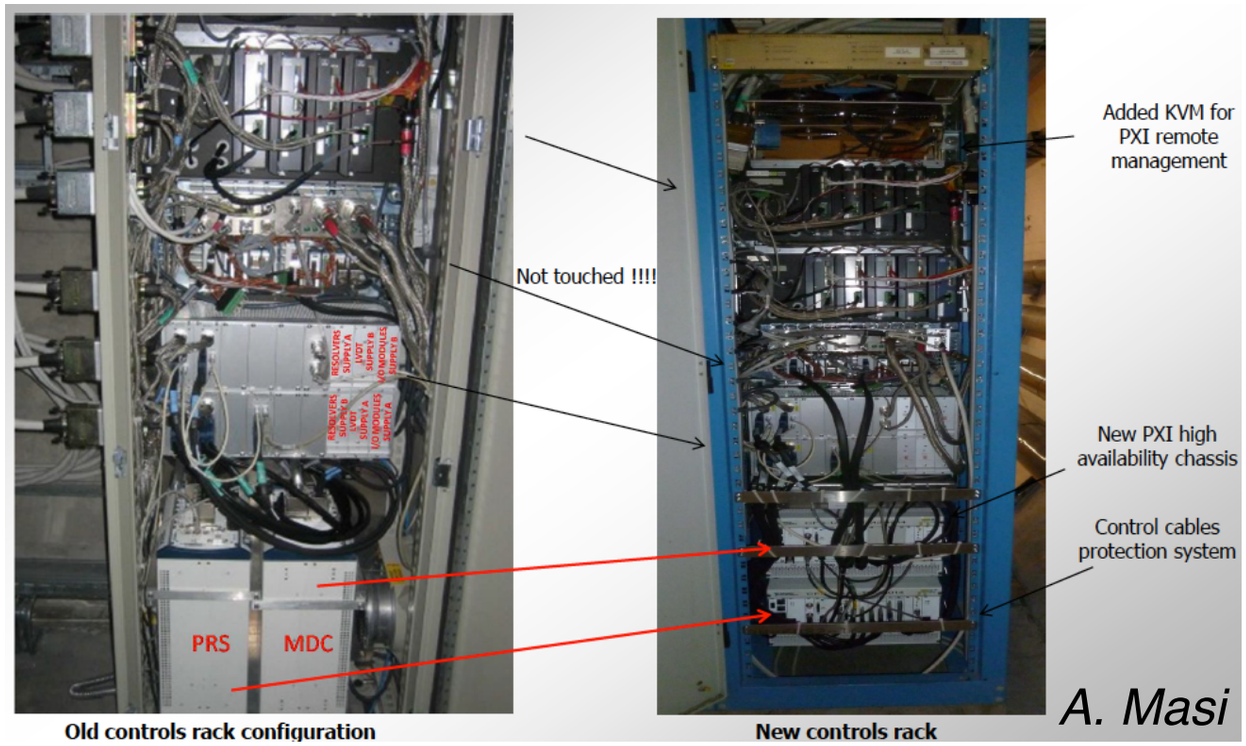
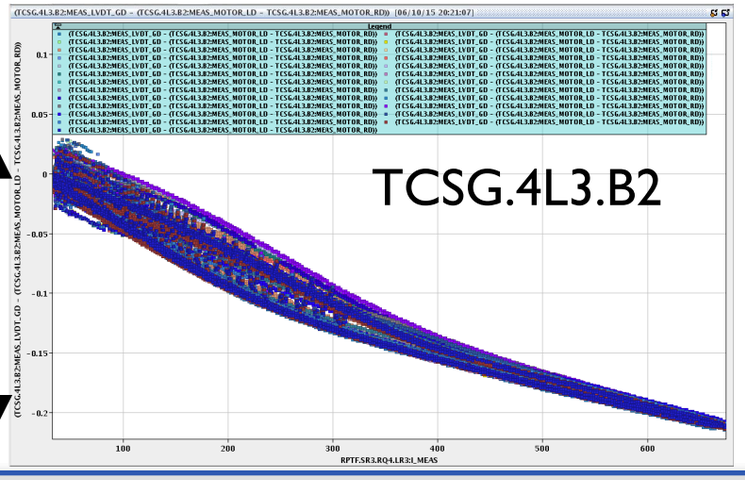
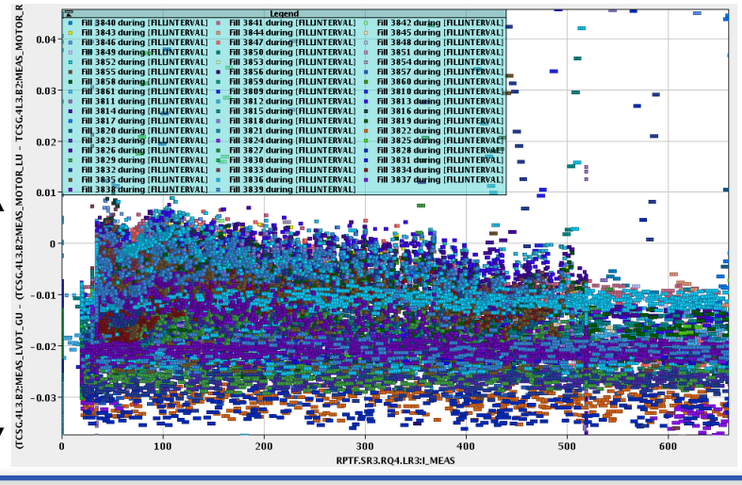


  - During Run 1, EM interference from nearby quads found to affect some IR3 collimator LVDTs. 10 sensors on 5 collimators now replaced with a new design (I2PS) (A. Danisi):

200 µm drift





30 µm spread

2015 HW commissioning

- New devices: updating of configuration databases, logging, LSA parameters etc
- LVDT calibration, interlock response to power cut & PRS reboot, RBAC
- Collimator temperature interlock tests
- Machine protection tests: 86 collimators x 18 limits = **1548 tests** executed in 2 days.

➡ First major test campaign since 2011.

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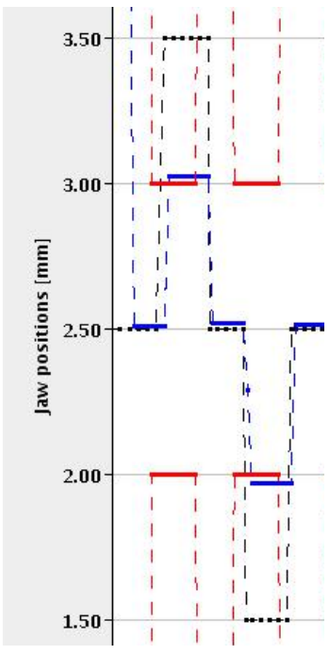
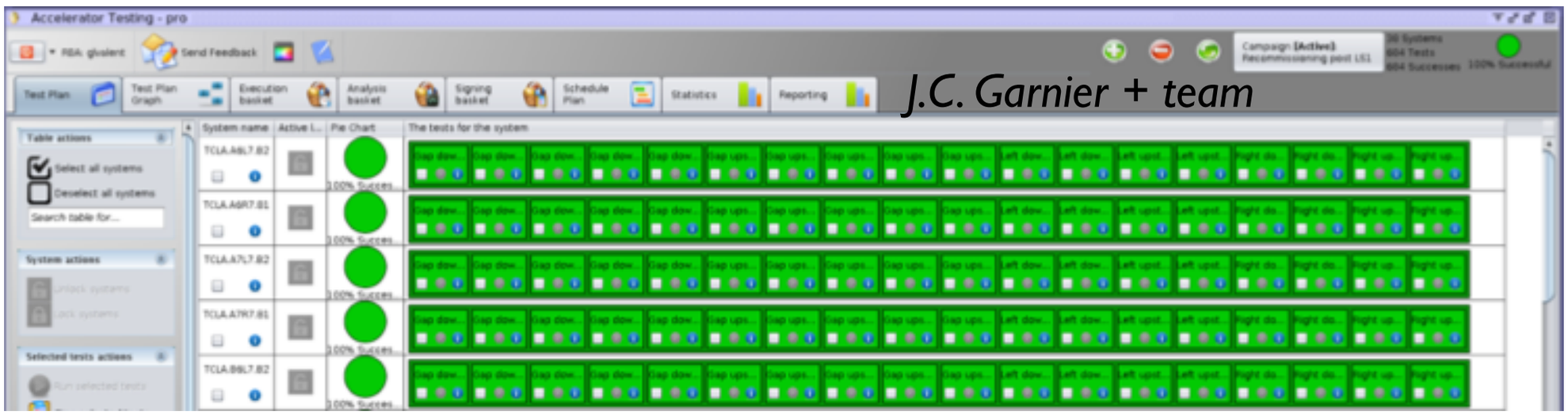
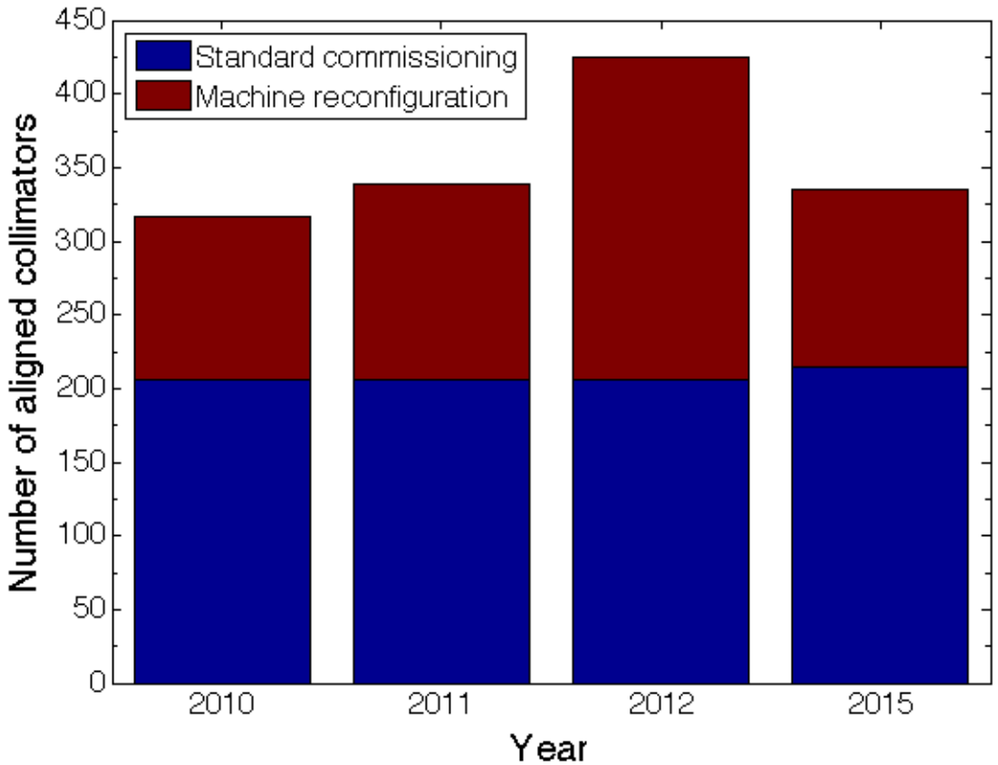
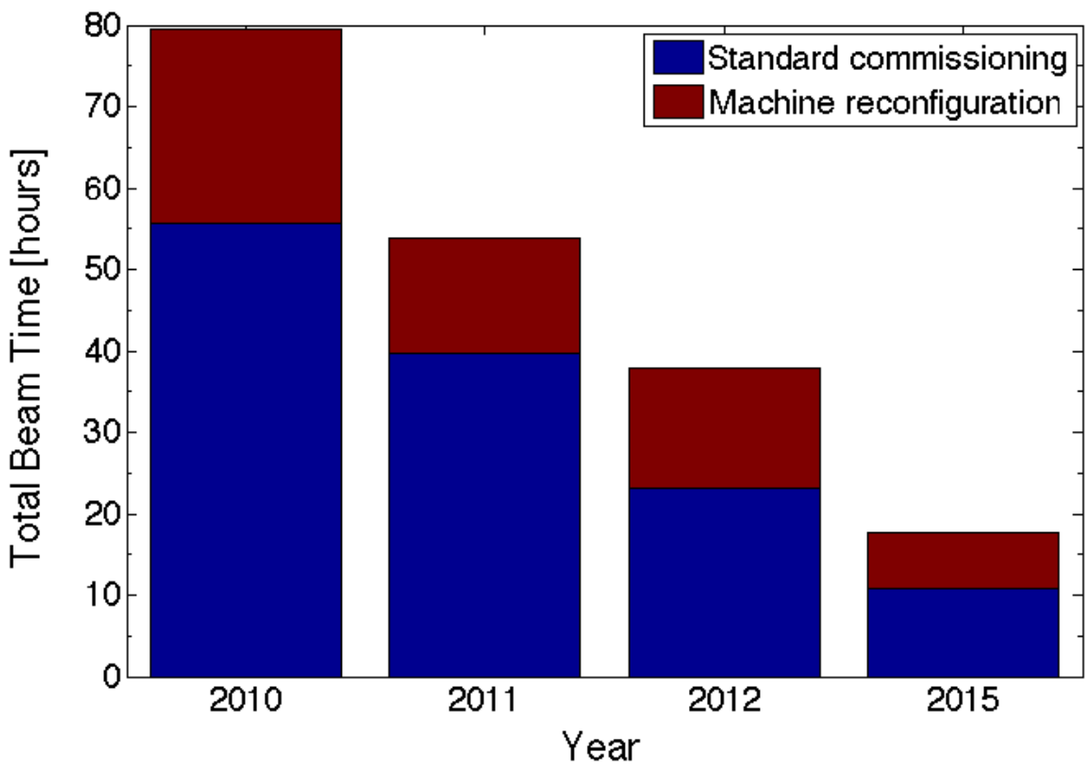




2015 beam commissioning

- **Beam-based collimator alignment**
  - Required to measure the beam centers and sizes at the collimator locations for OP settings generation.
  - Initially done only with BLM-based technique due to unavailability of DOROS BPM electronics.
  - Feedback loop for BLM and BPM-based alignment moved to FESA class in LS1.
  - Alignment time for all 86 collimators now down to 4 hours from ~20 hours in 2010.





2015 beam commissioning

- Collimator settings used throughout standard β* = 80 cm machine cycle:

Coll Family	Injection [σ]	Flat Top [σ]	Squeezed [σ]	Physics [σ]
TCP IR3	8.0	15.0	-	-
TCSG IR3	9.3	18.0	-	-
TCLA IR3	12.0	20.0	-	-
TCP IR7	5.7	5.5	-	-
TCSG IR7	6.7	8.0	-	-
TCLA IR7	10.0	14.0	-	-
TCSP IR6	7.5	9.1	-	-
TCDQ IR6	8.0	9.1	-	-
TCT IR1/2/5/8	13/13/13/13	37/37/37/37	13.7/37/13.7/15	-
TCL 4/5/6 IR1/5	parking	parking	parking	15/15/parking*

*When TOTEM inserted, TCLs in IP5 @ 15/35/20.

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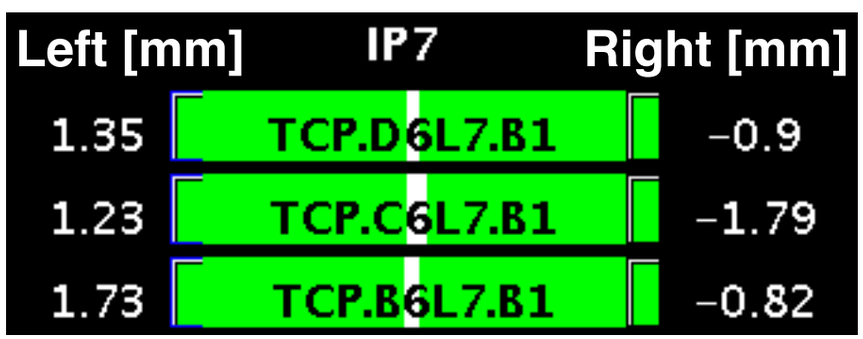

down to 2.2 mm gap in IR7!

Validation of settings

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- Loss map validation strategy:

➡ Initially, require 3 fills per point in the machine cycle.

➡ Post-TS2 and proposal to keep also for 2016:

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FLAT TOP	YES	ALTERNATE SIDE	ALTERNATE SIDE	Cancelled?	1
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COLLISIONS	YES	YES	YES	YES	3

B. Salvachua

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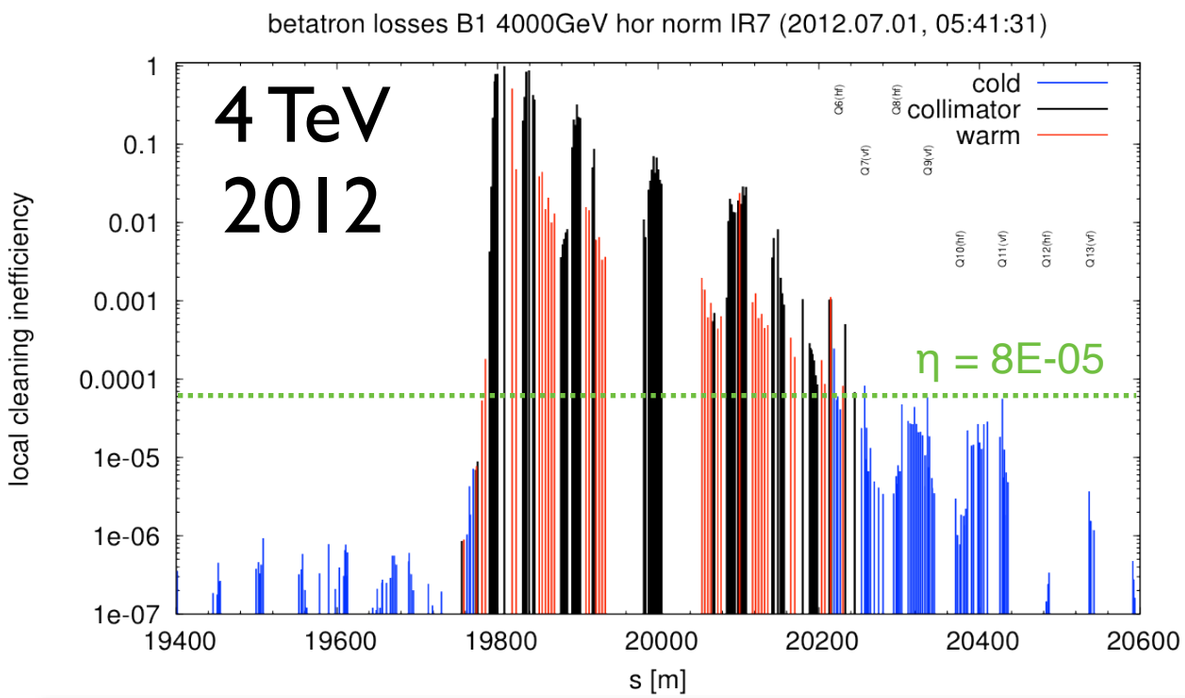

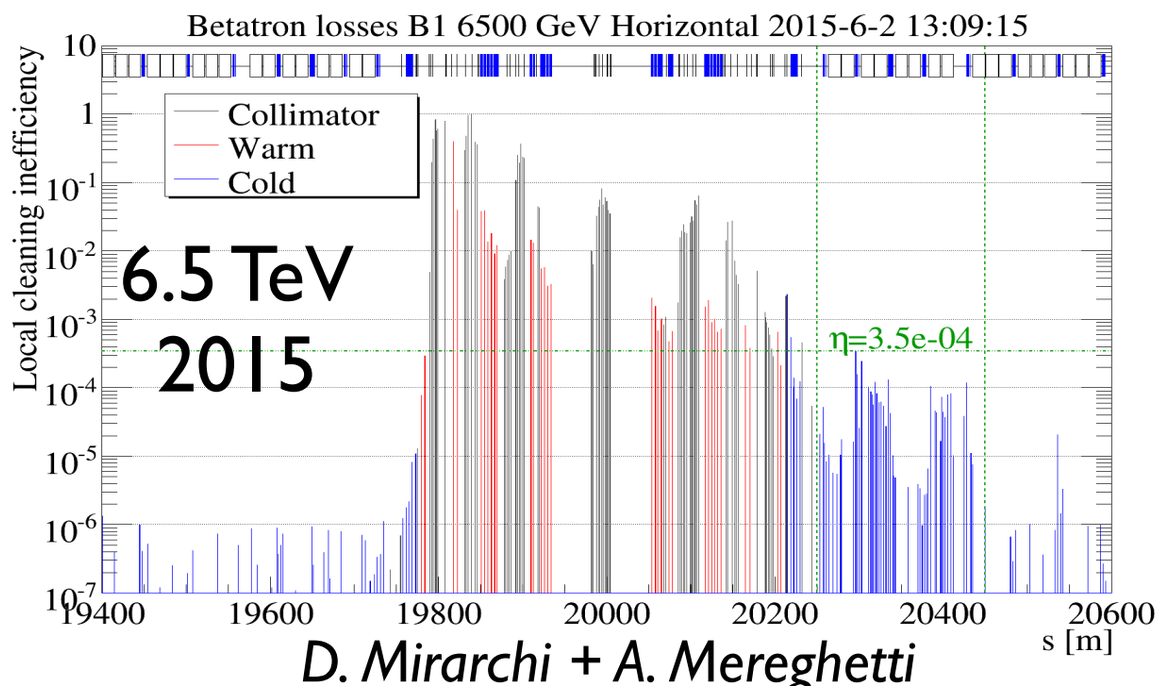

D. Mirarchi + A. Mereghetti

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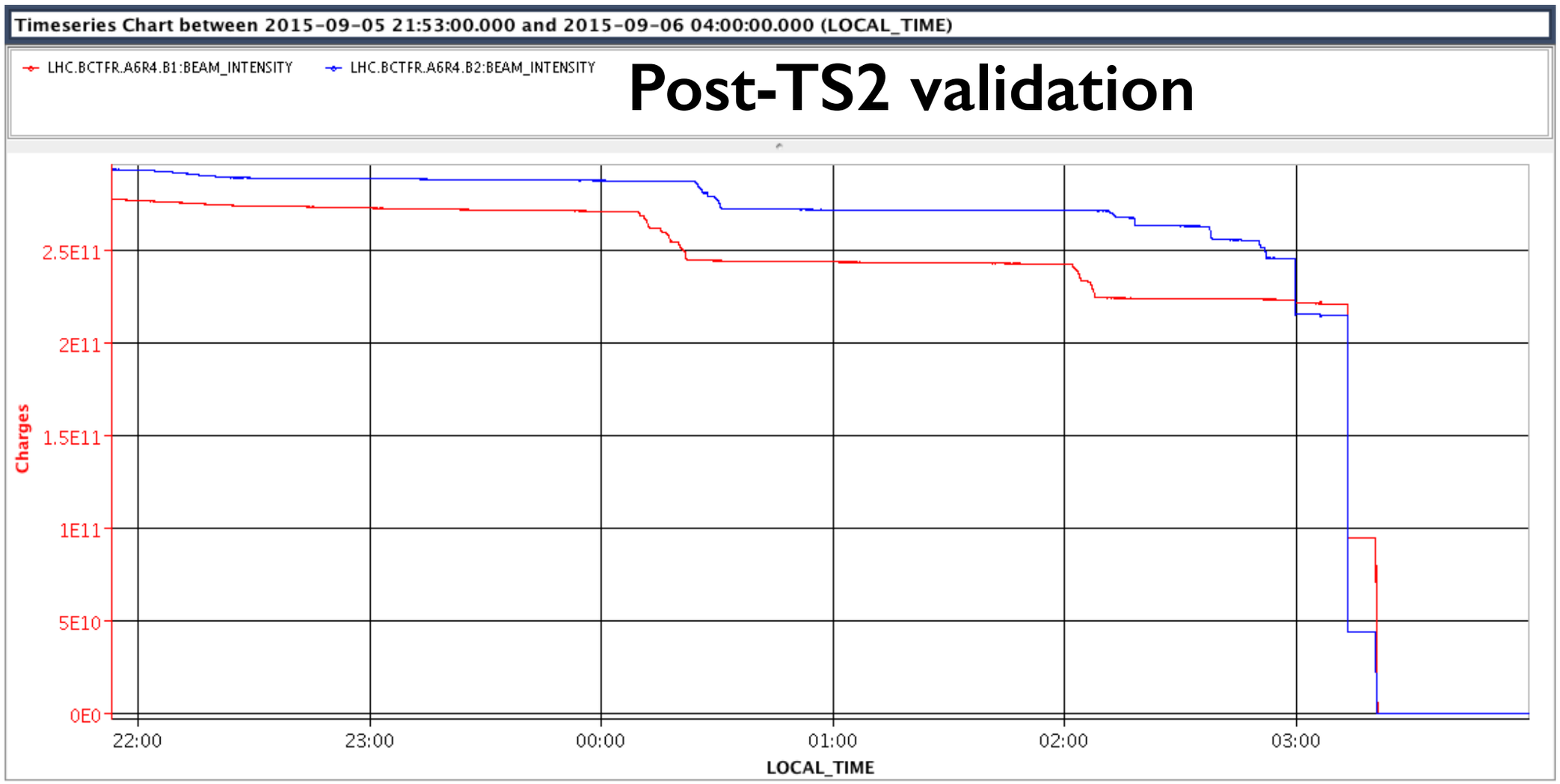

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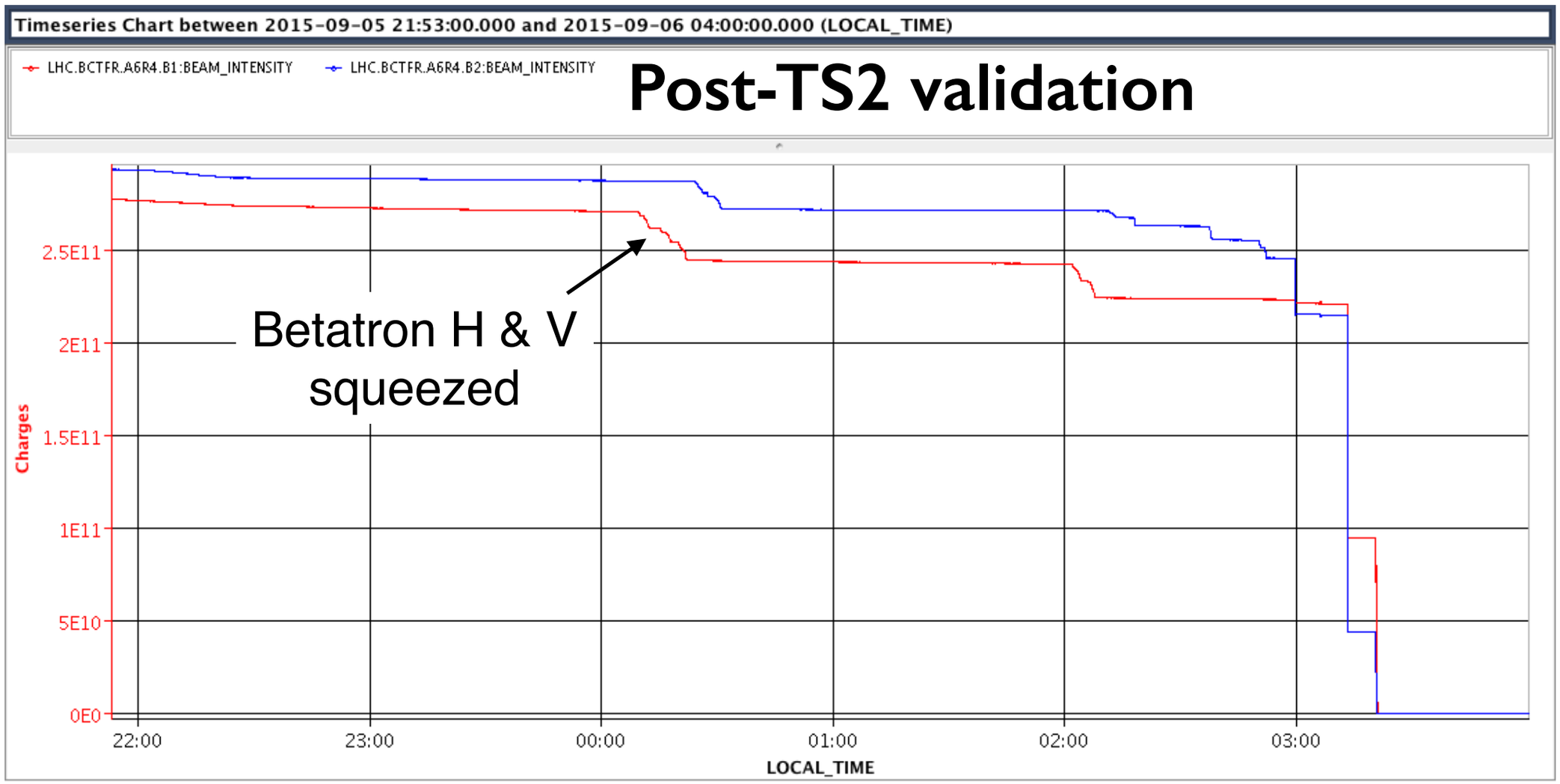

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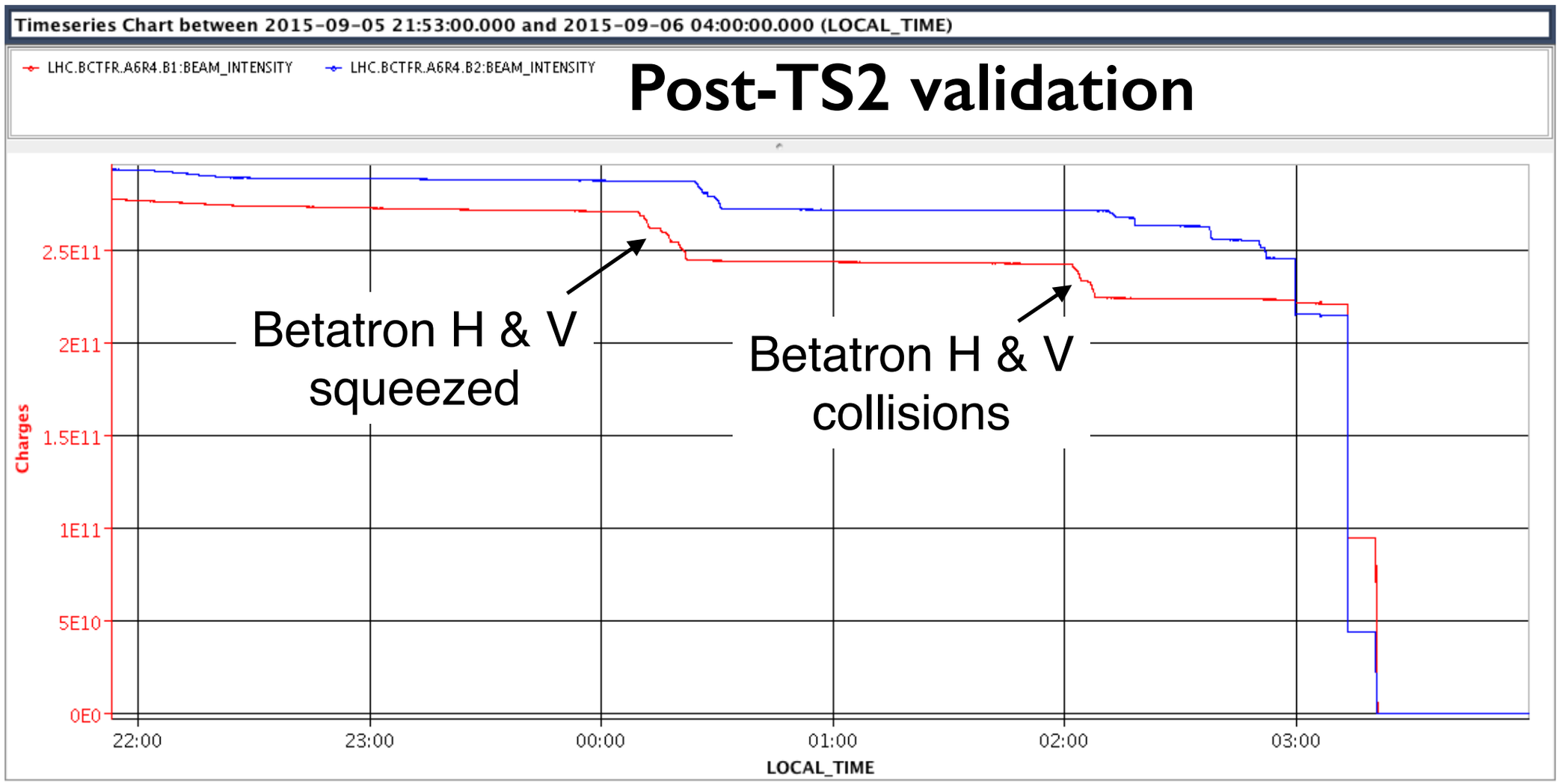

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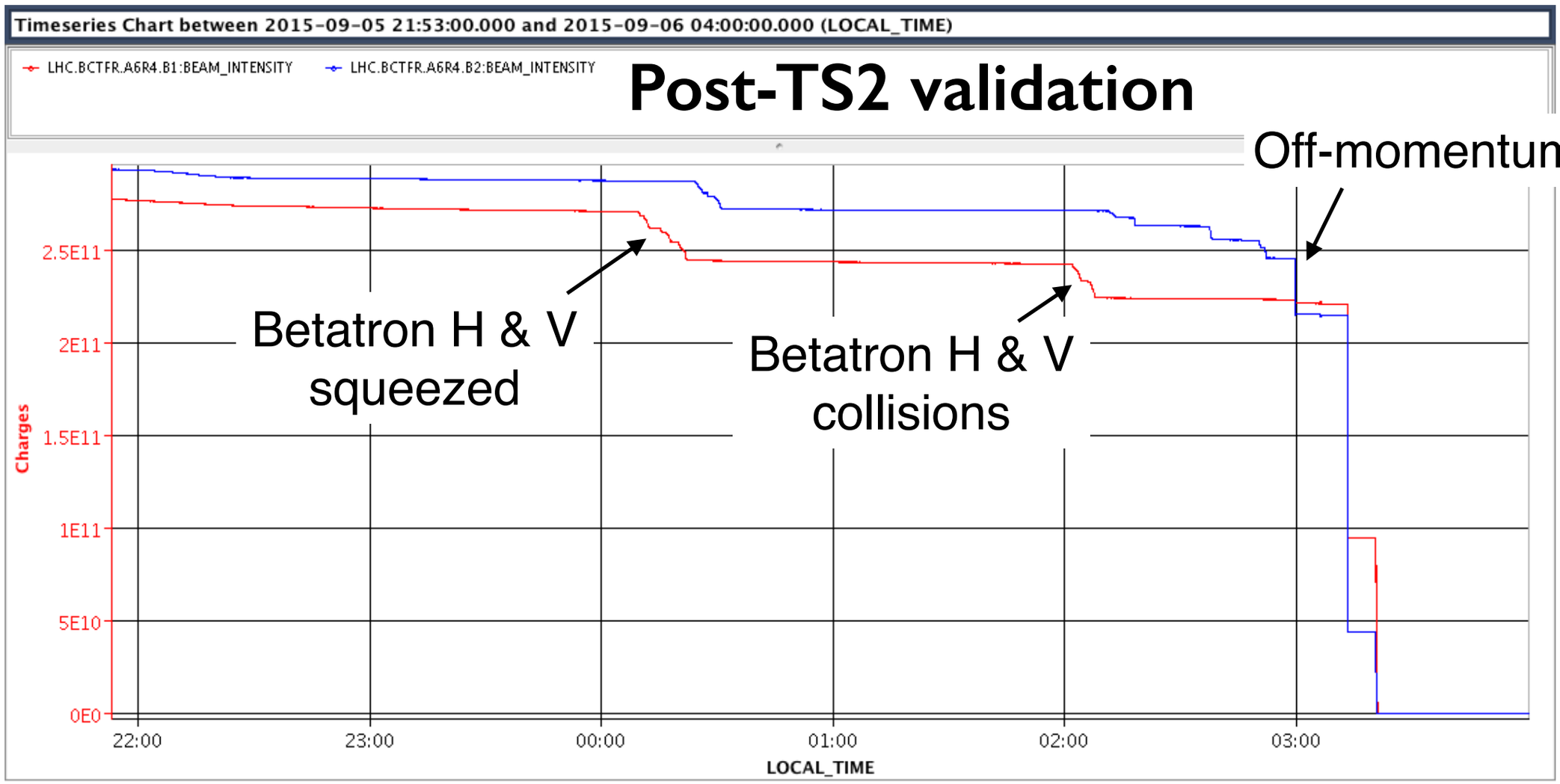

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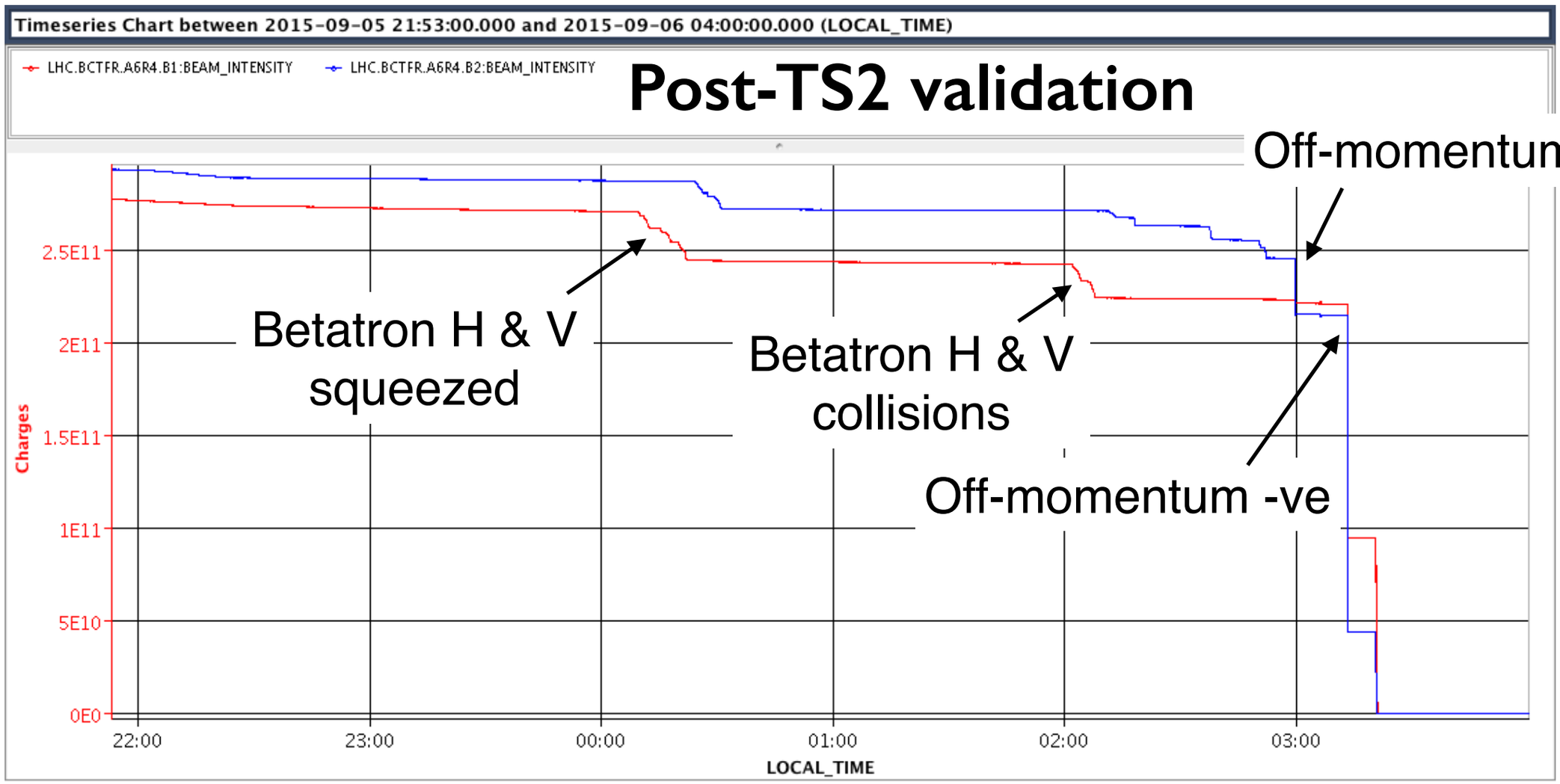

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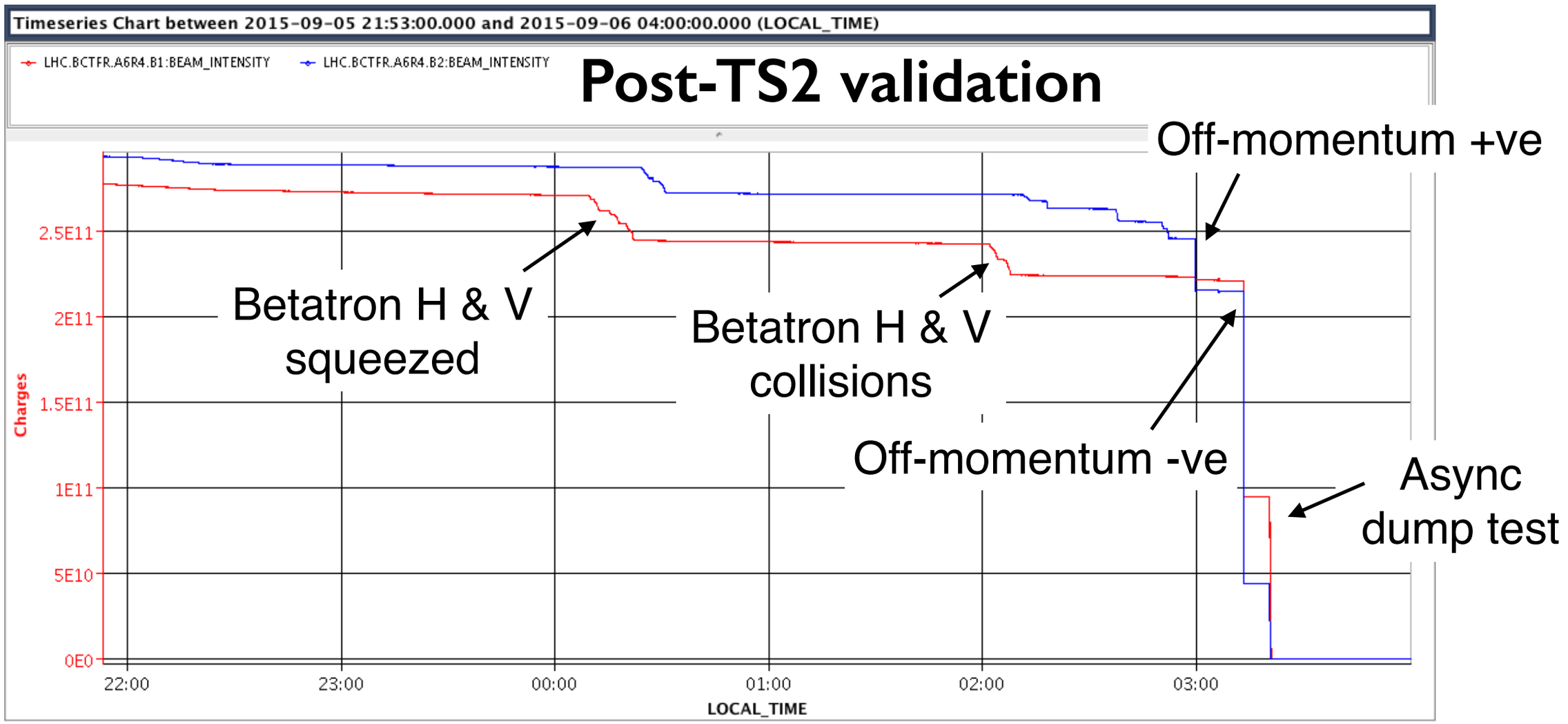
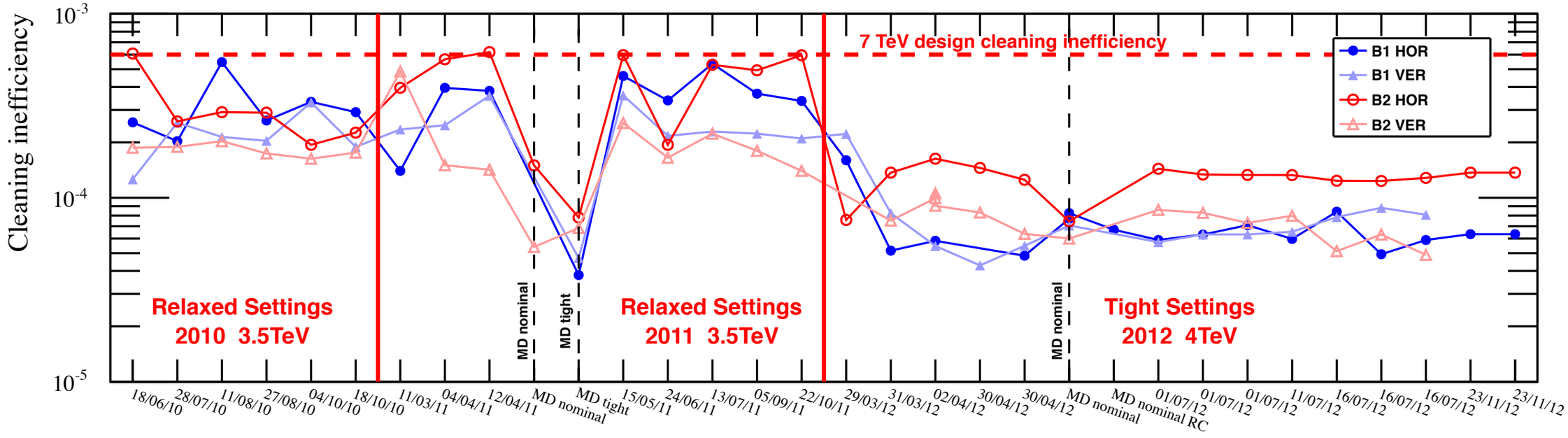


Cleaning performance

Run I



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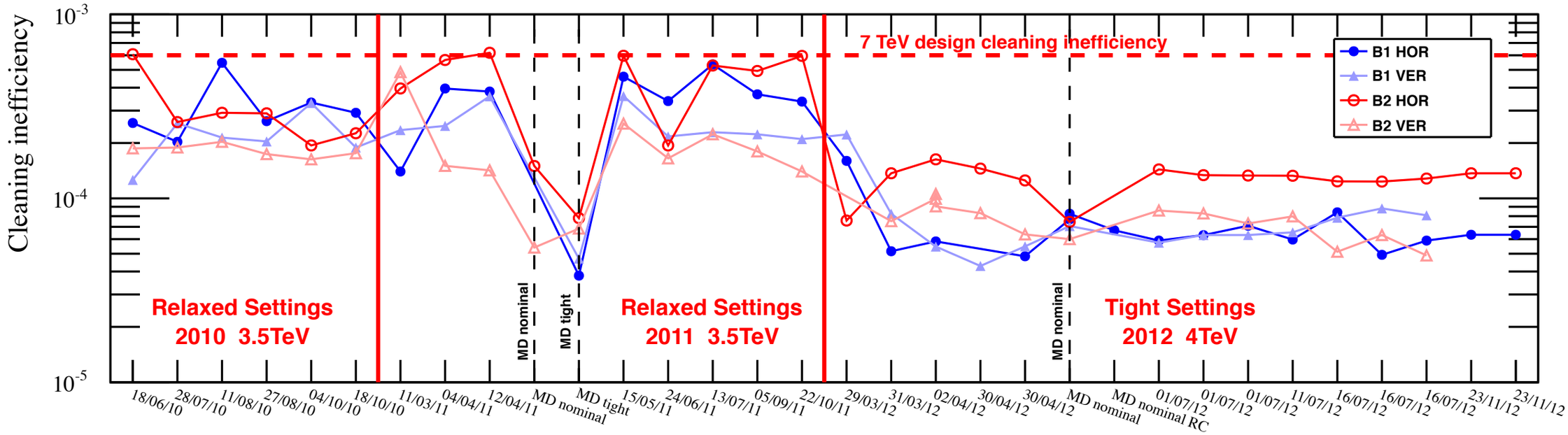
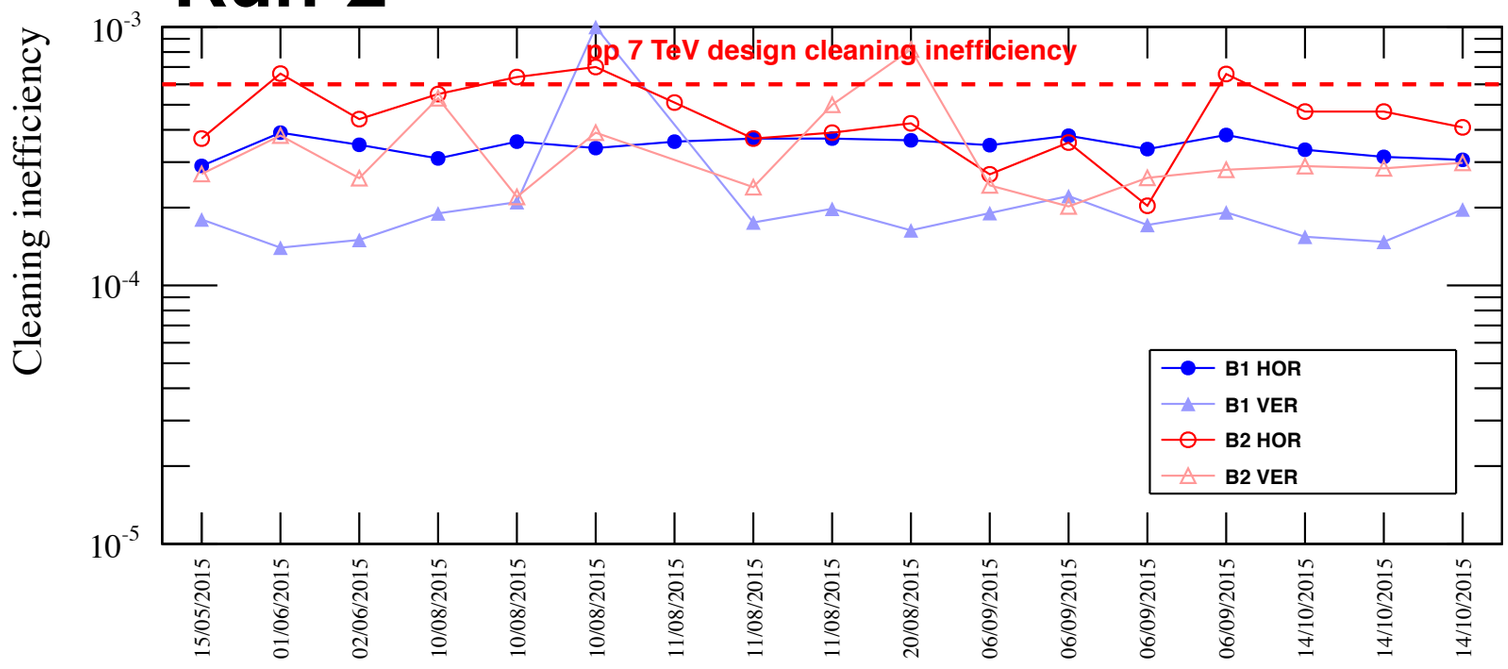


Run 2



B. Salvachua

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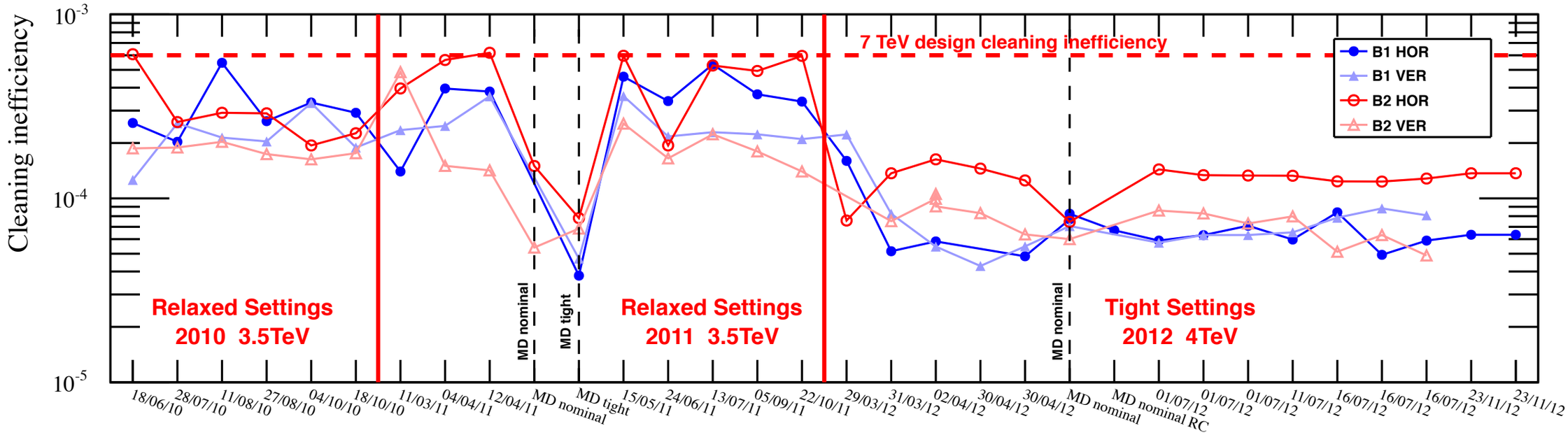

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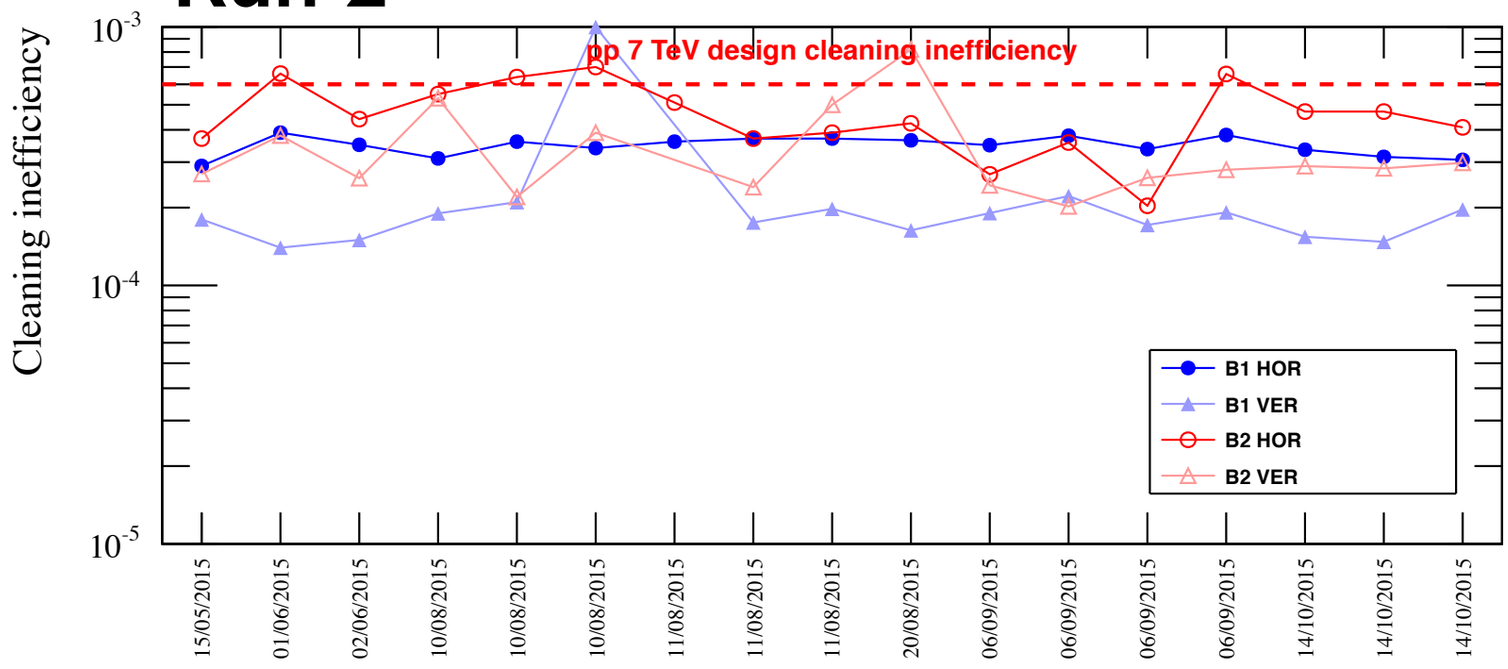

B. Salvachua

Worse cleaning than in 2012, but continue stable performance with only one full alignment per year!

Collimation with heavy ions

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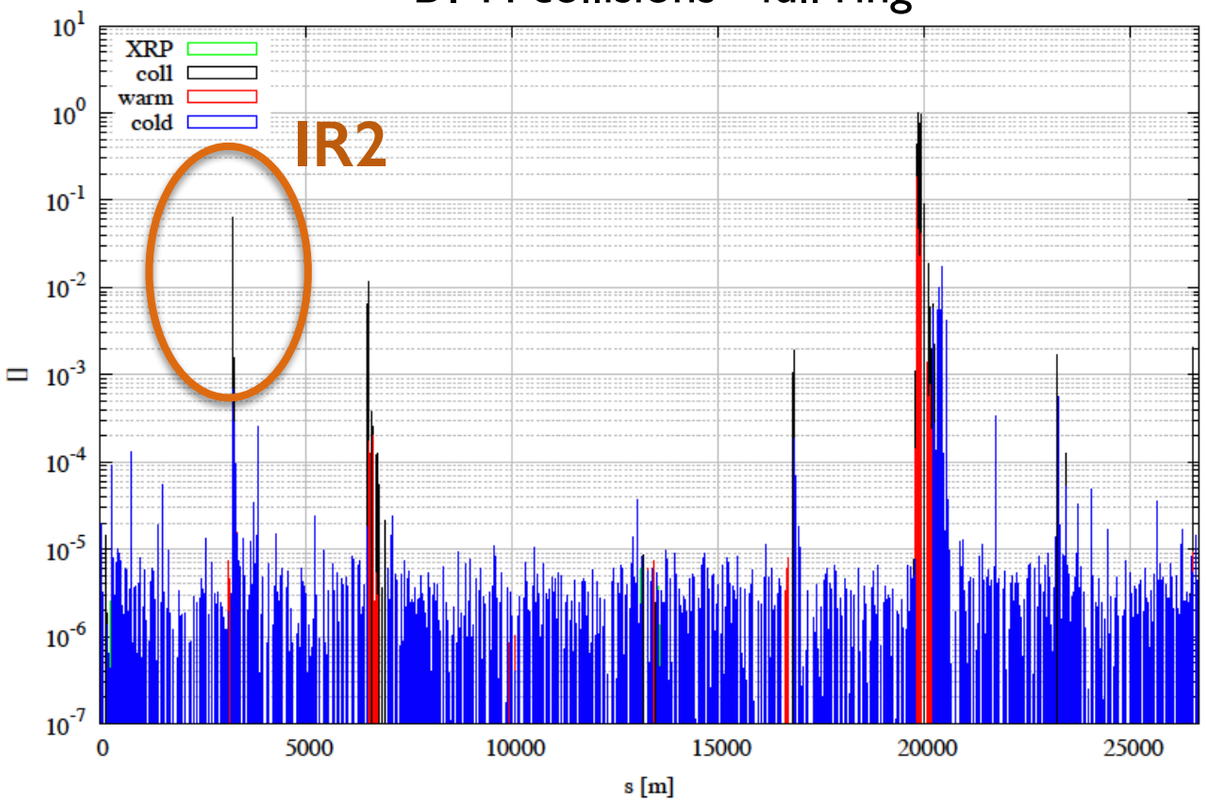
- Cleaning worse than protons as expected (almost single stage).
- Higher losses in B1 H TCT in IR2 could be connected to observations of higher background in ALICE.

B1 H collisions - full ring



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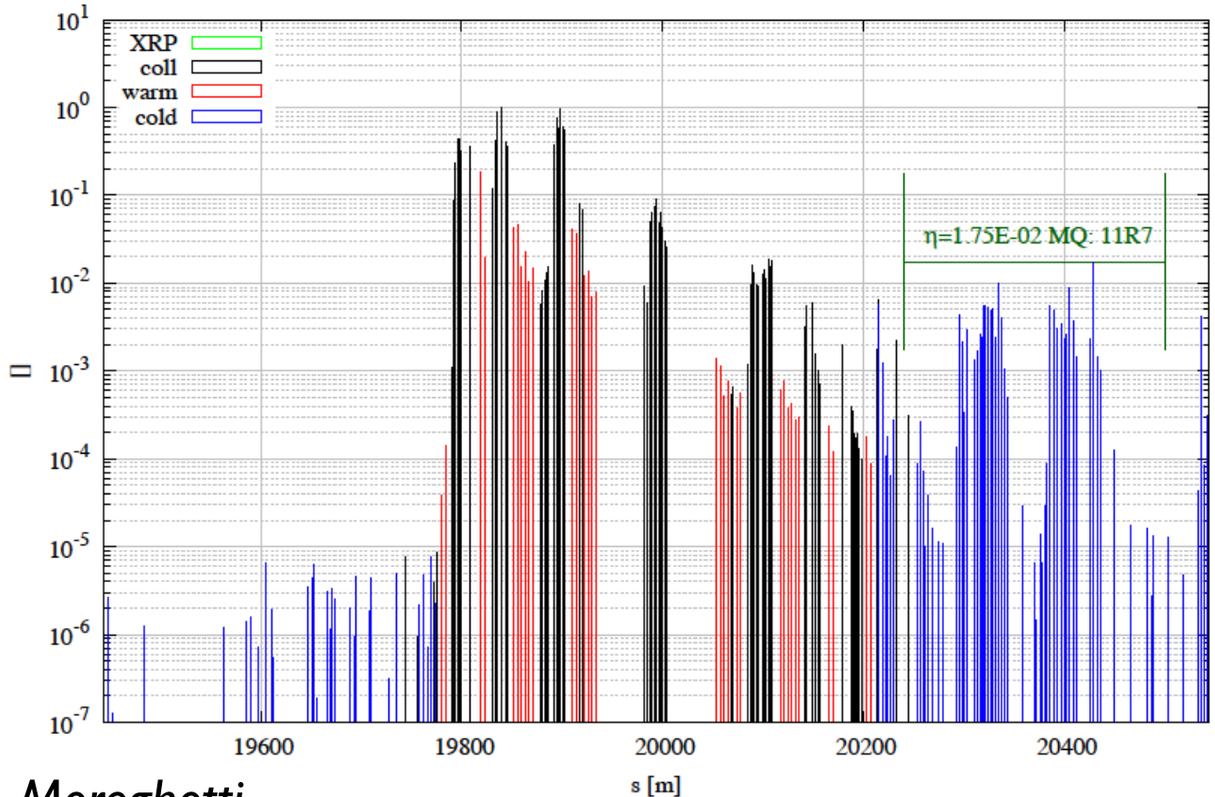

A. Mereghetti

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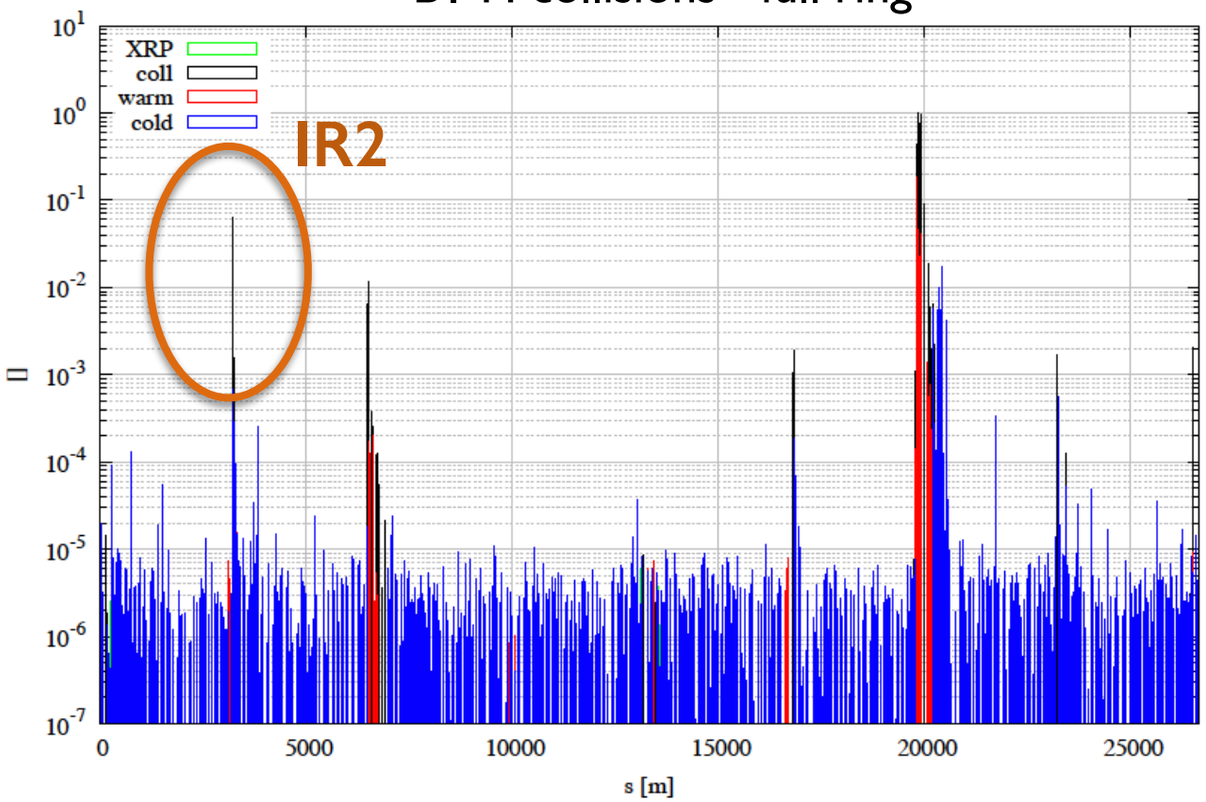

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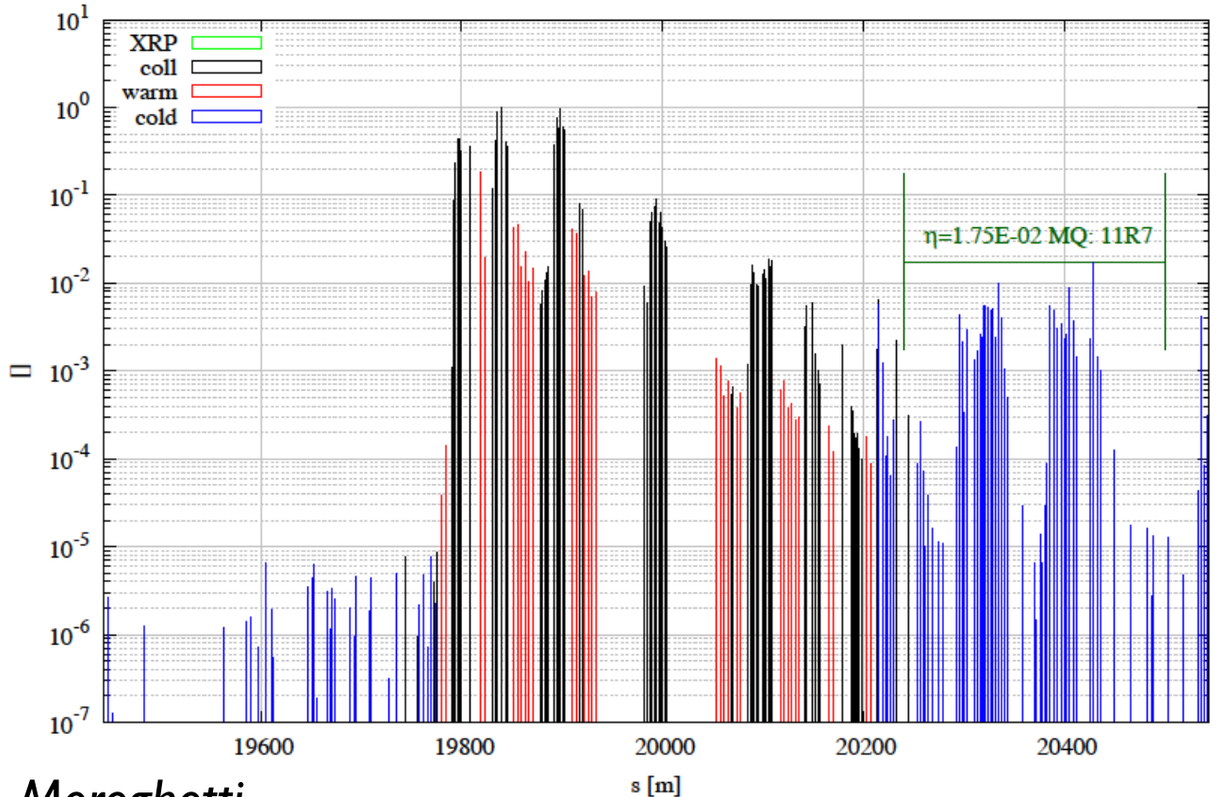

A. Mereghetti

- Possible mitigation measures were tested (e.g. asymmetric IR7 TCP settings) and likely to work
  - ➡ After tracking simulations, EOF study done in shade of IP2 polarity switch validation (P. Hermes, R. Bruce).
  - ➡ Not implemented due to time constraints (as requested from ALICE).

Issues encountered in the year

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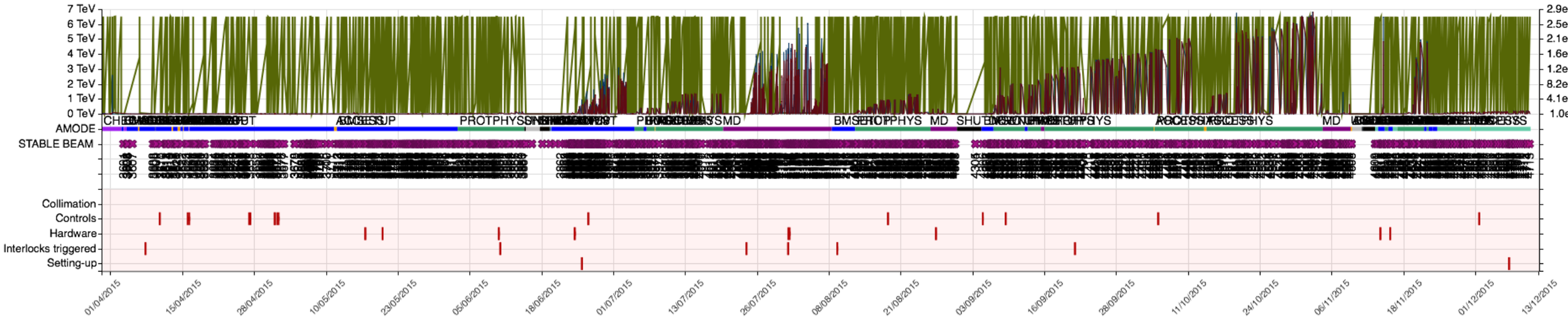
- **Fault statistics for the collimation system**



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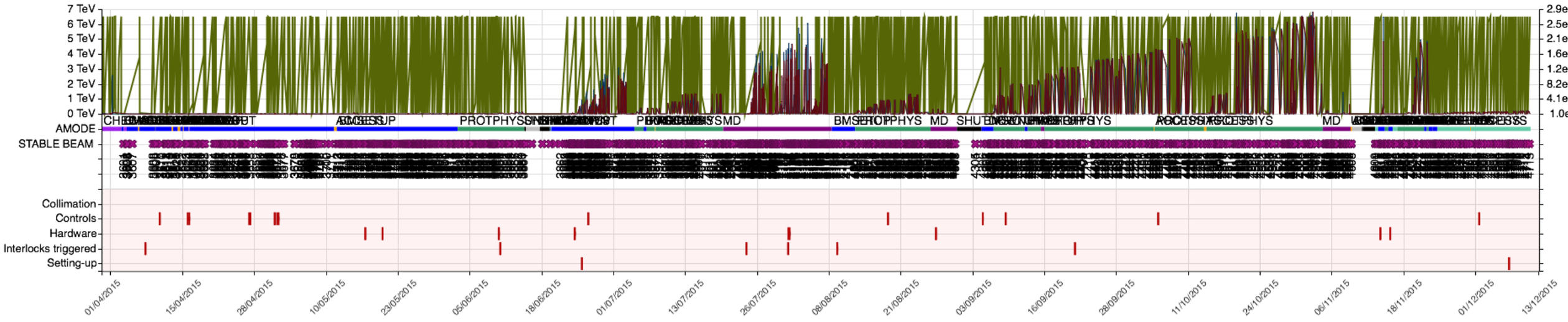

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- **Survey and alignment:**
  - **TCLA.D6R7.B2:** large offset of +3 mm wrt other IR7 collimators discovered during beam commissioning. Survey measurements done but not possible to correct in TS. Collimator stable and we could correct for the offset with the right settings. Fiducialization measurement and re-alignment foreseen for YETS.
  - **TCL.6L5.B2:** Tilt of > 2 mrad observed during beam commissioning (400% measured-to-nominal beam size ratio). Fixed in TS2.
  - No impact on OP, able to workaround using appropriate settings.

Collimator BPMs: Commissioning

- Motivation for installation:

  ➡ Faster alignment ⟶ respond more quickly to IR configuration changes

  ➡ Reduce orbit margins in the TCSP-TCTP hierarchy: more room to push β*

- DOROS BPM electronics available for IP1 during beam commissioning, then all collimators available for MD in July.

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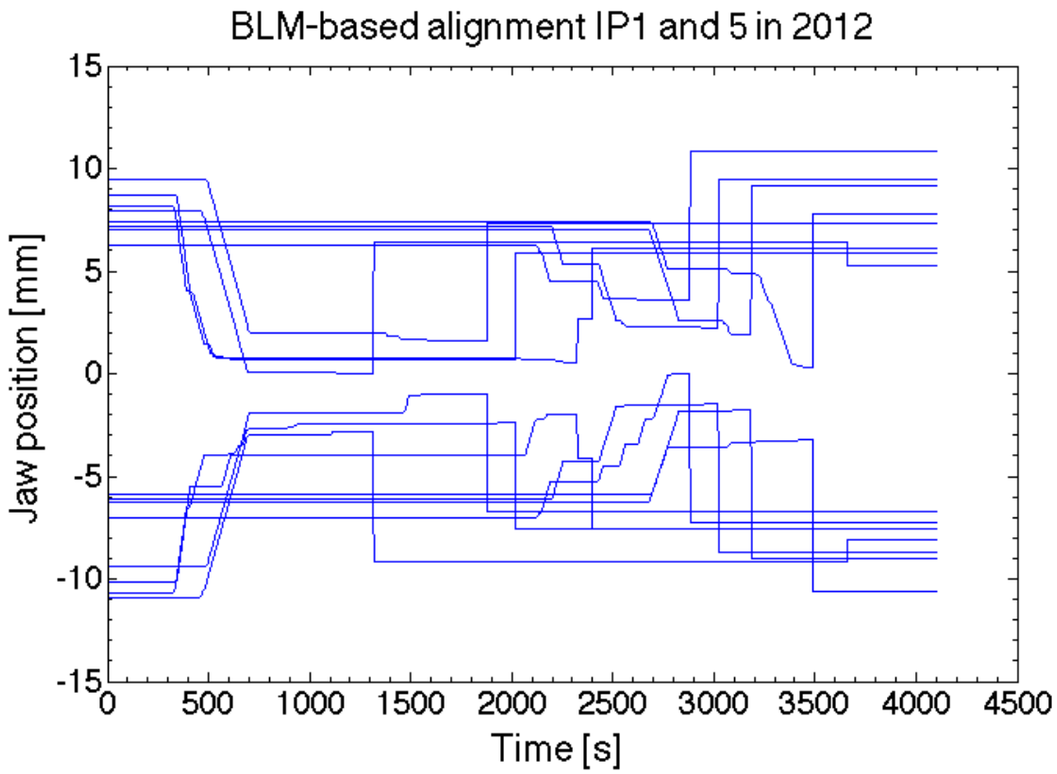

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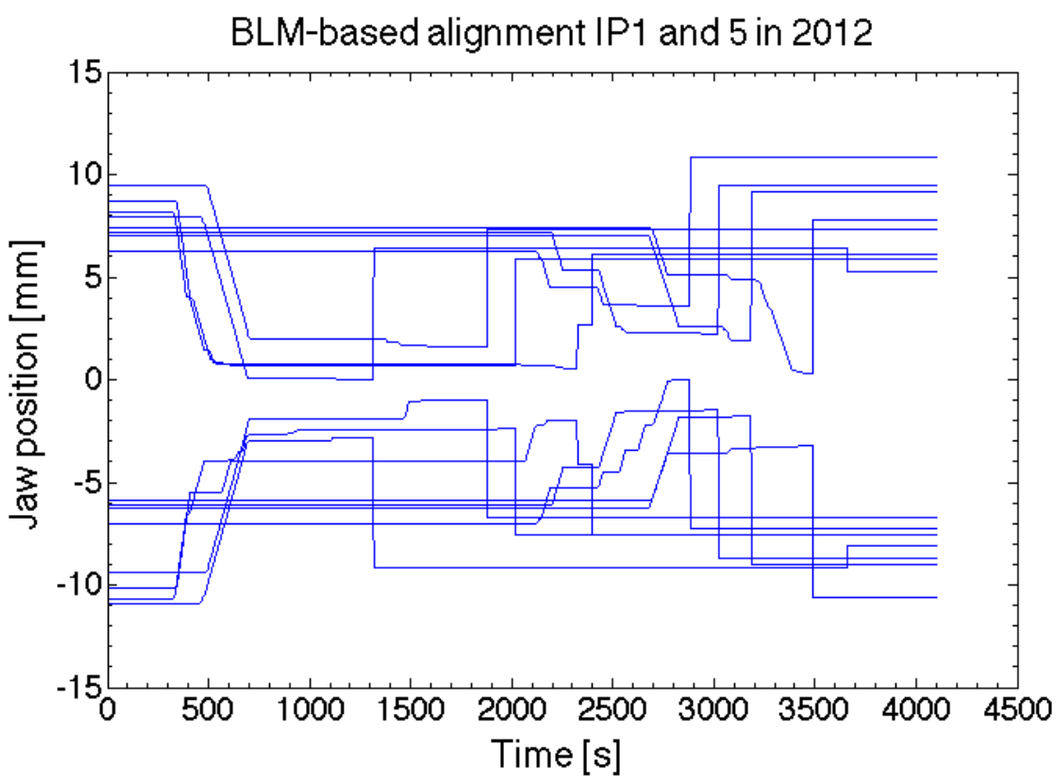

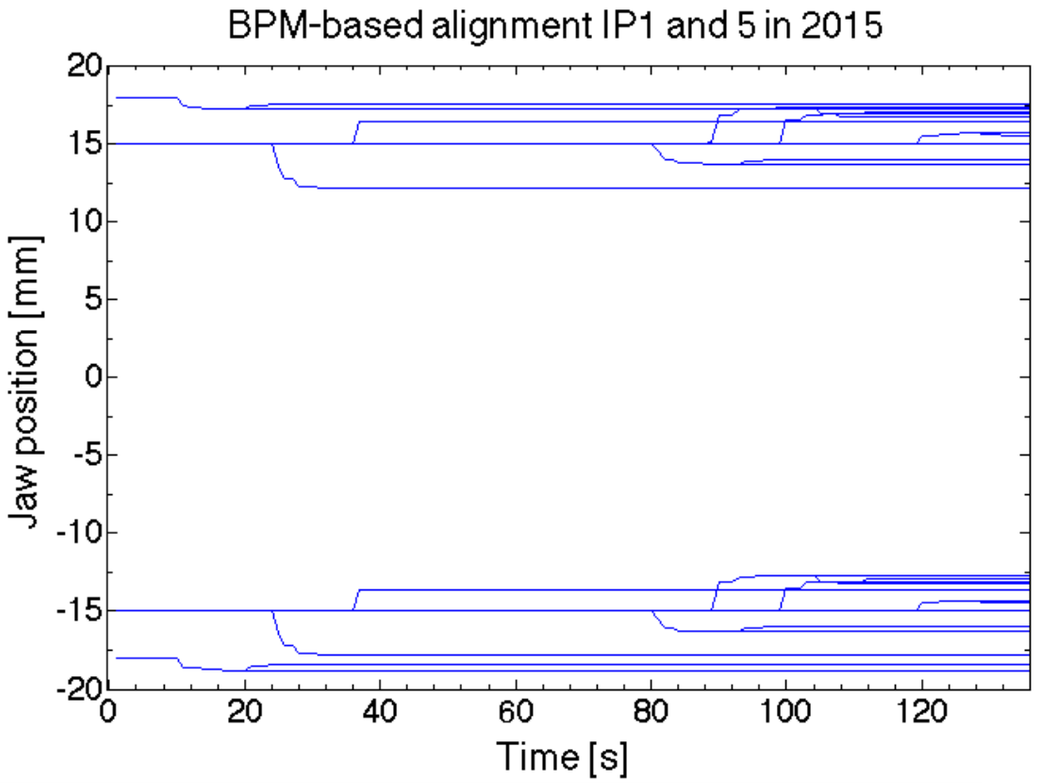

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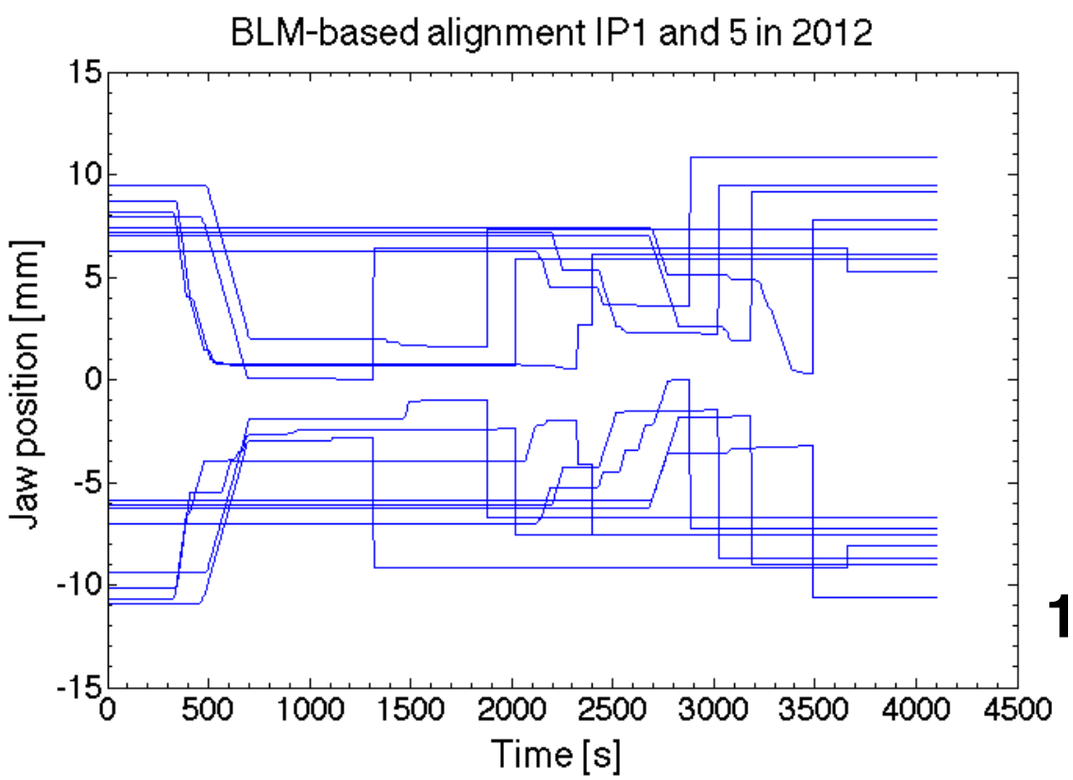
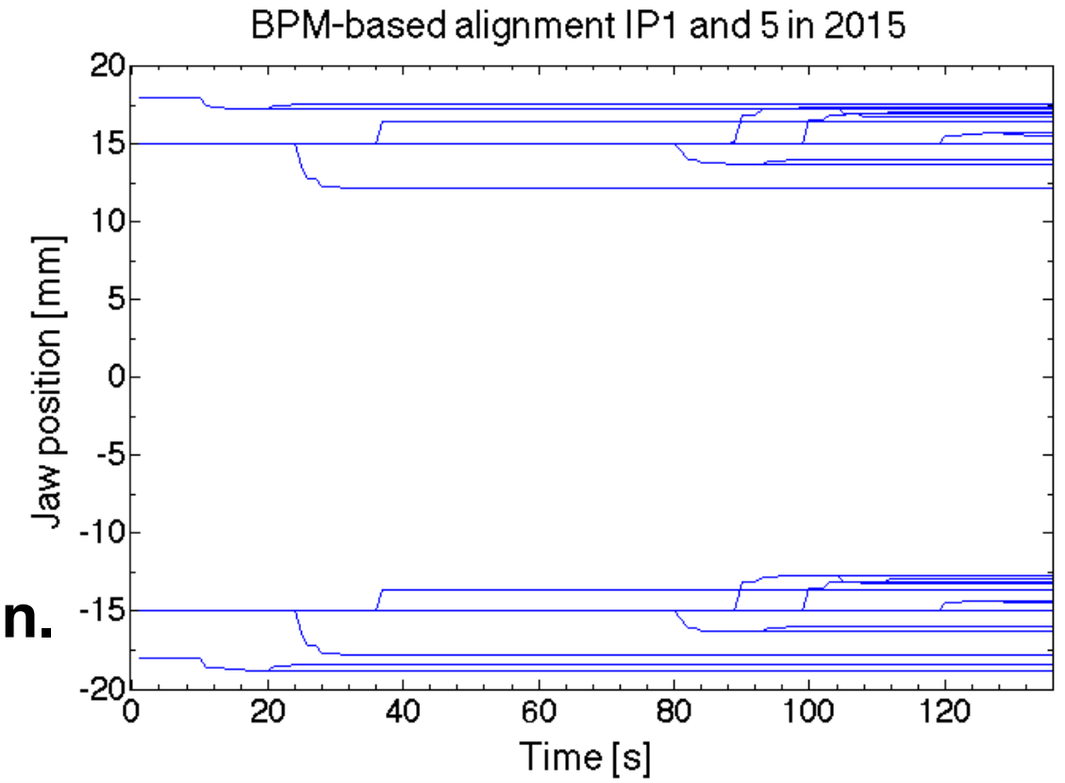


1 hour vs 2 min.



Collimator BPMs: Fill-to-fill stability

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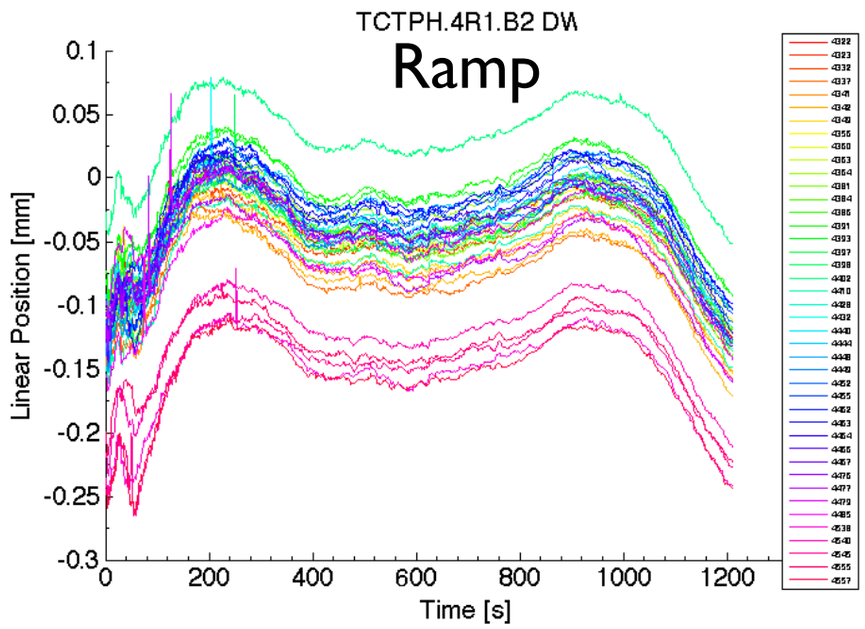
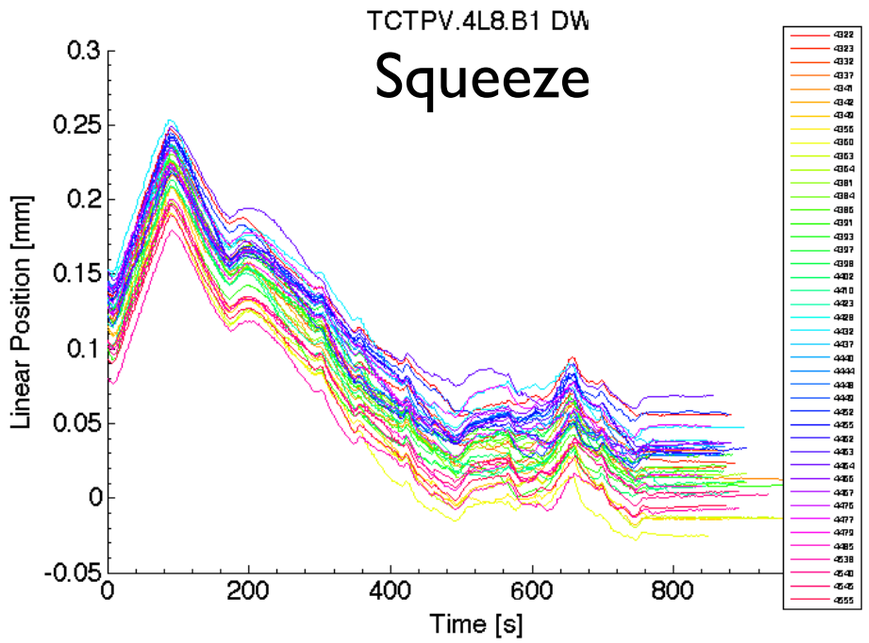
- **Dynamic parts of the cycle:** Trends correlated with standard BPMs nearby: feed-forward into collimator functions for 2016?





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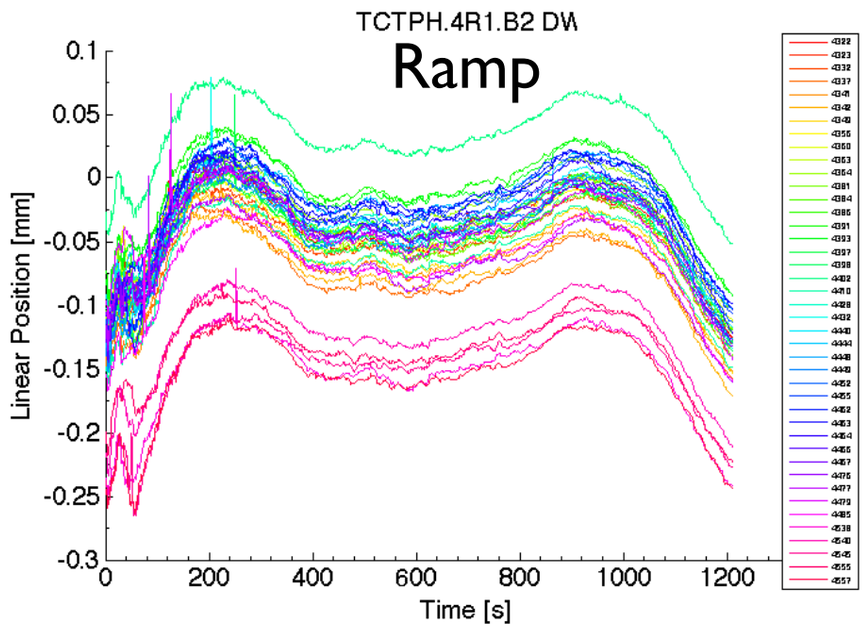
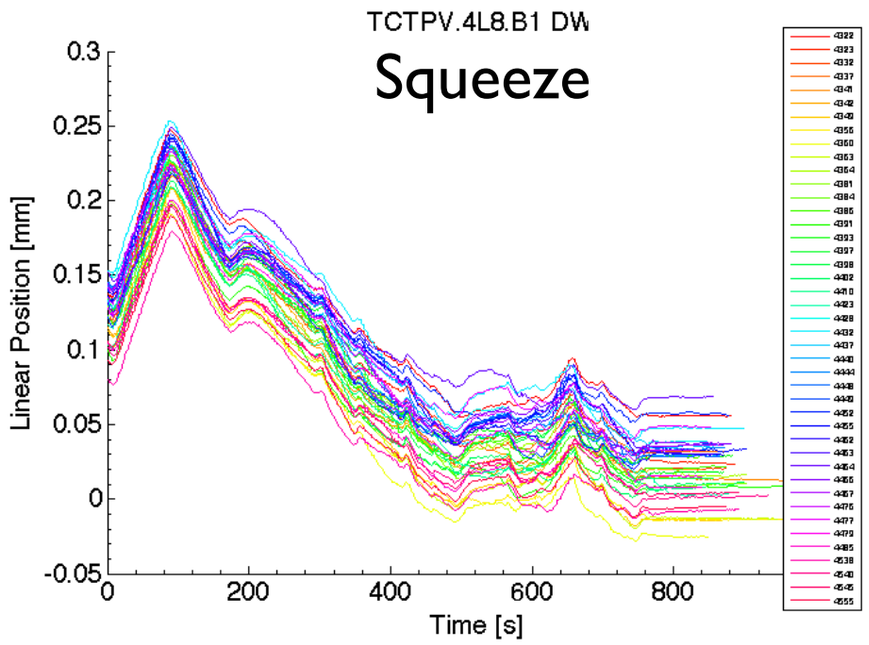
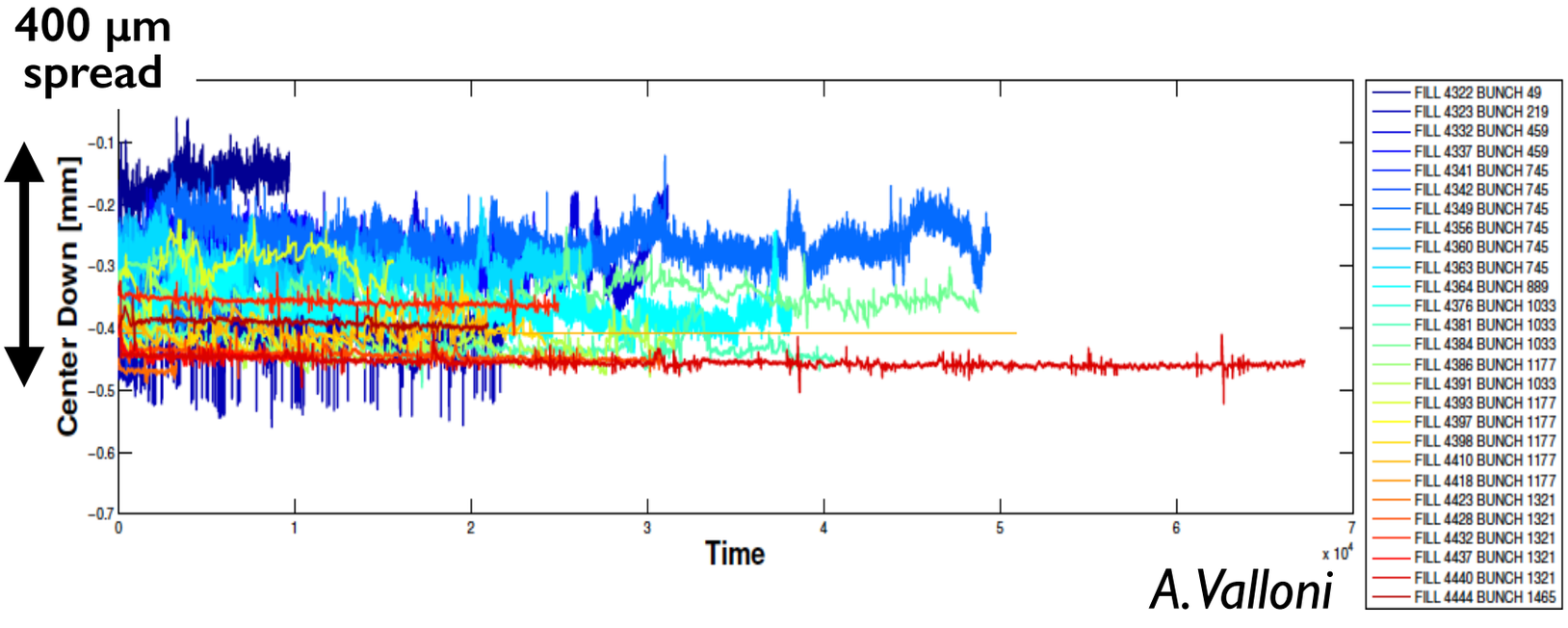
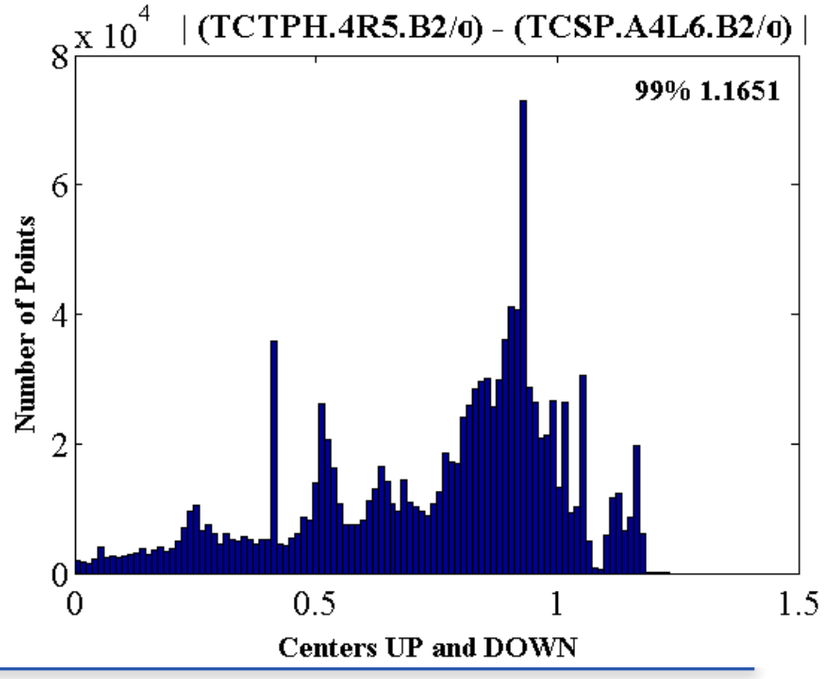




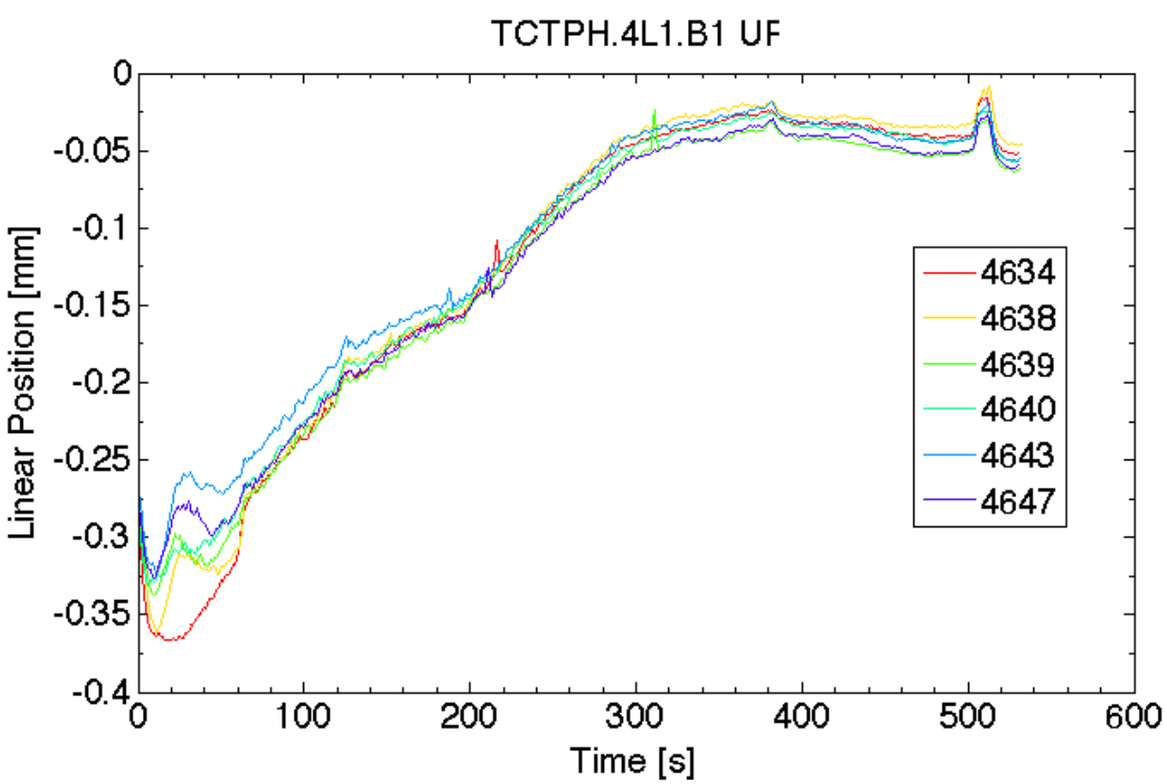
- **Stable beams:** Intra-fill stability better than inter-fill stability.

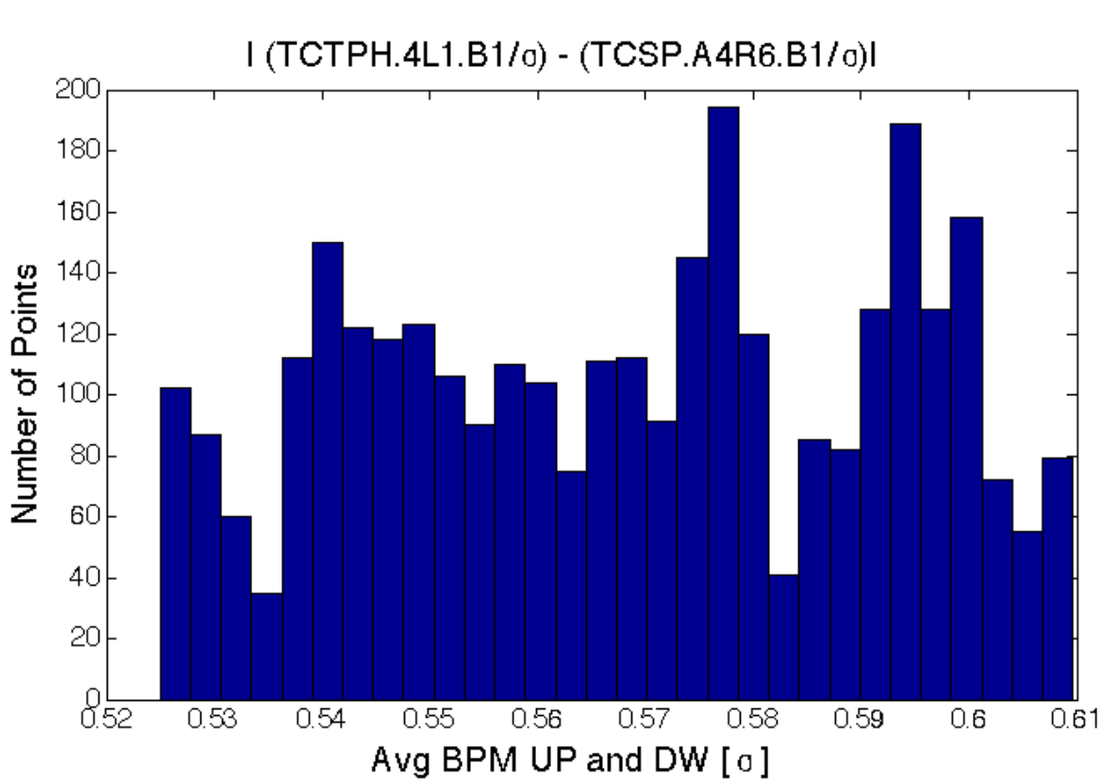




Collimator BPMs: Fill-to-fill stability

- **Combined ramp & squeeze during p-p reference run @ 2.51 TeV**
  - first experience with CRS with orbit measurements directly at the collimators.
  - data are useful input for possible CRS implementation in 2016.
  - to be compared in detail to MADX simulations and see if we have a good understanding of the dynamic behaviour.





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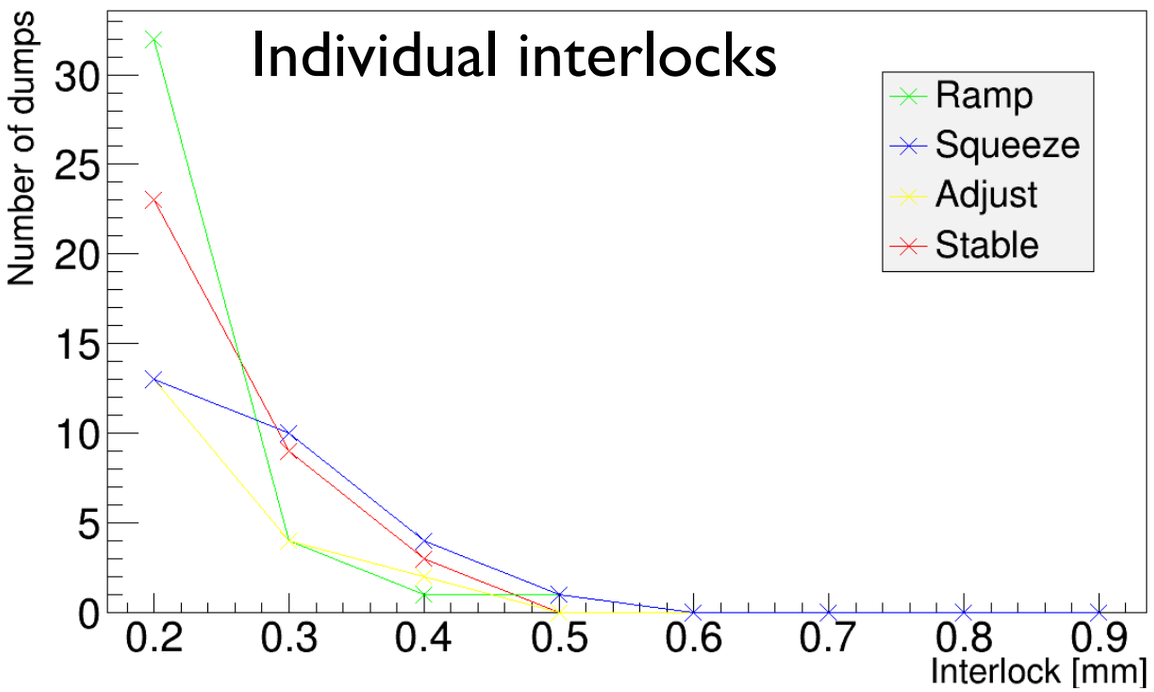

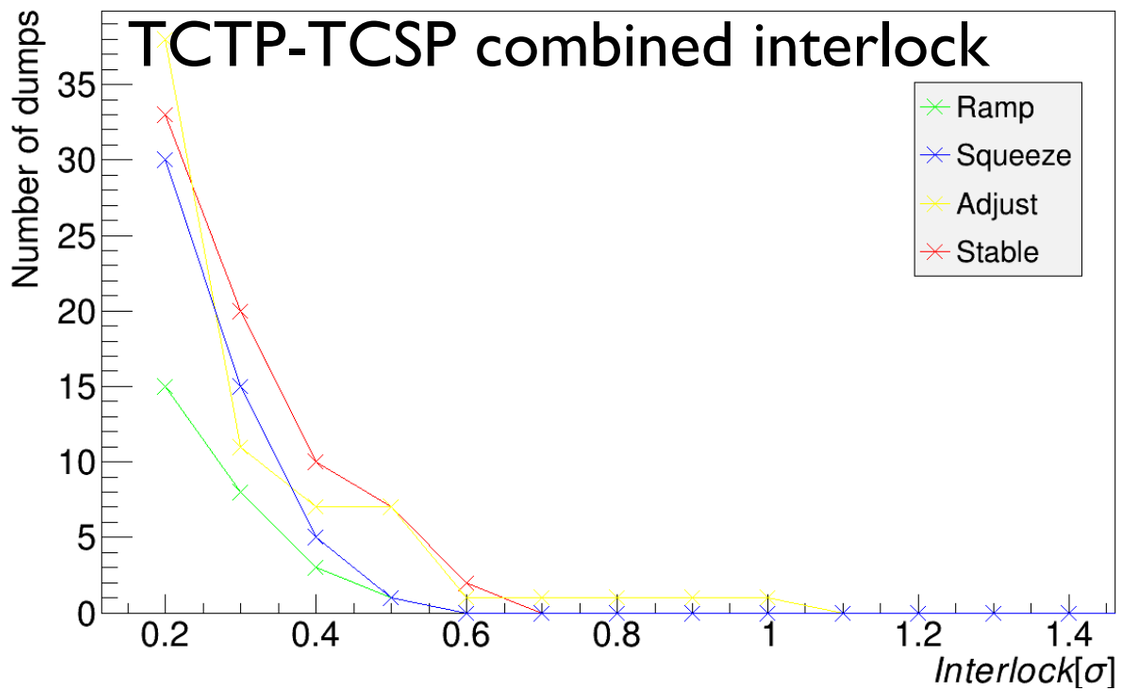

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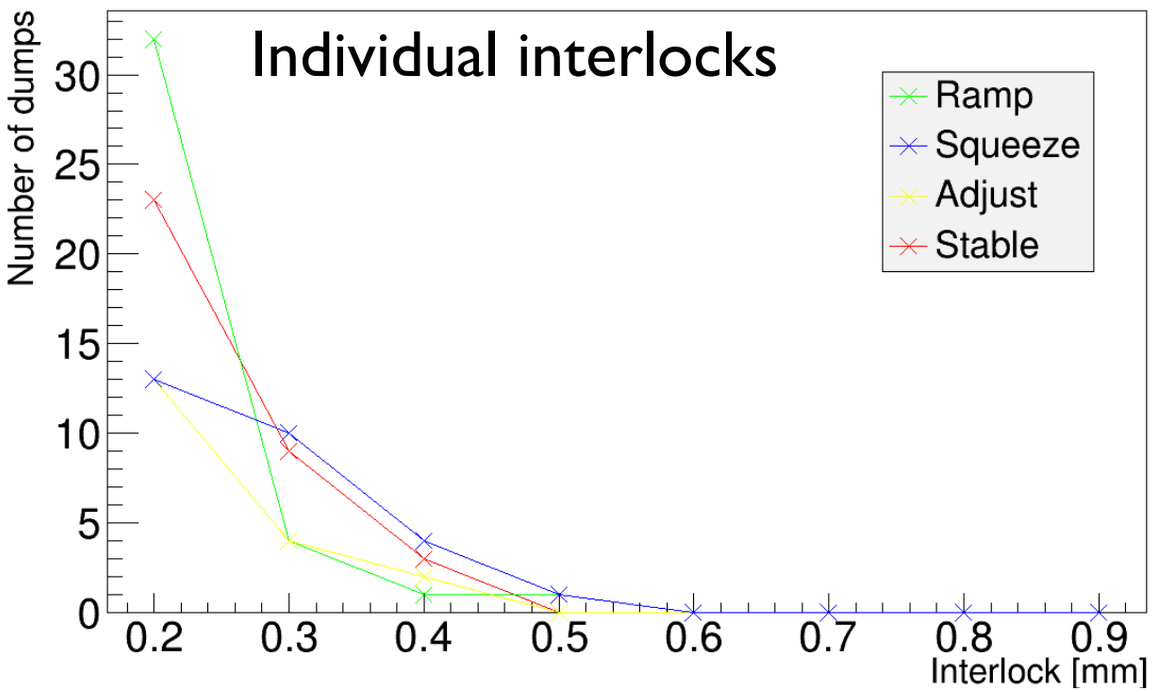

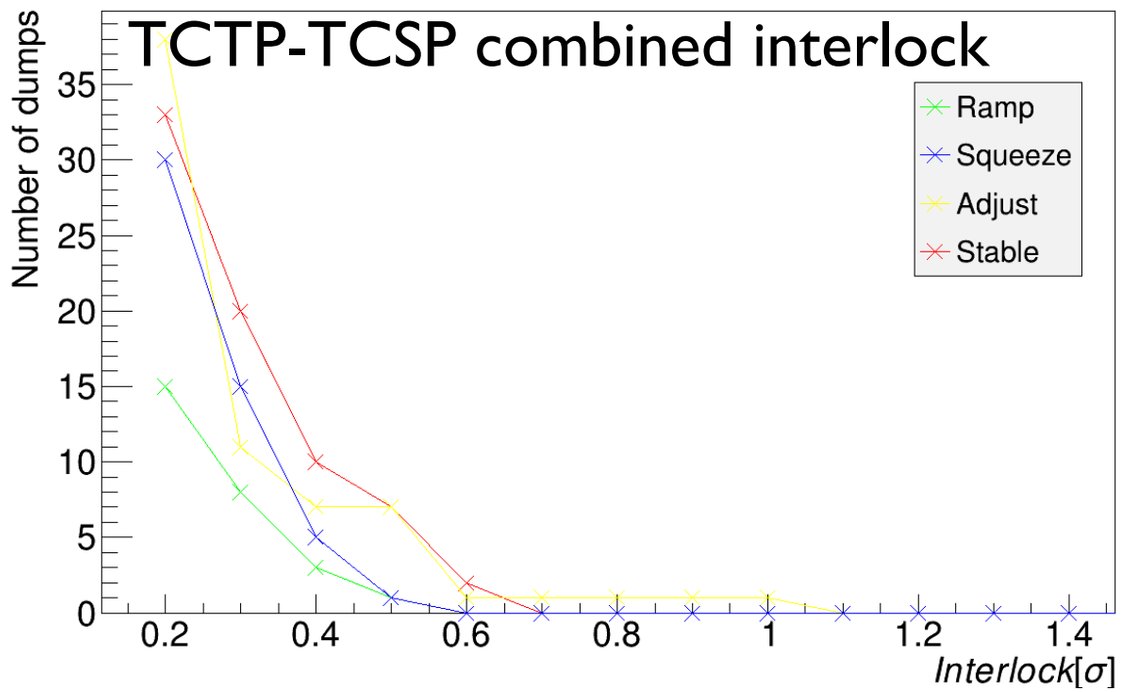

- Require 100% BPM FESA class reliability for interlocks (minor availability issues being mitigated).

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- Don’t plan major changes to the control software, so we will only repeat a subset of MP tests that ensures that each IP BIC is tested.

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- Already using the embedded BPM collimators for fast alignment

  ➡ experience gained during 2015 MD will come in handy during the commissioning next year.

  ➡ hope to also profit from them to reduce the TCSP-TCTP collimator margins as one of the ingredients to push the β* reach in 2016.

  ➡ Dedicated commissioning time will be needed especially if they will be used for interlocks.