Observations and conclusions after TDI issue in IP8 Scrubbing Run: TDI, MKI and MKE interlocks

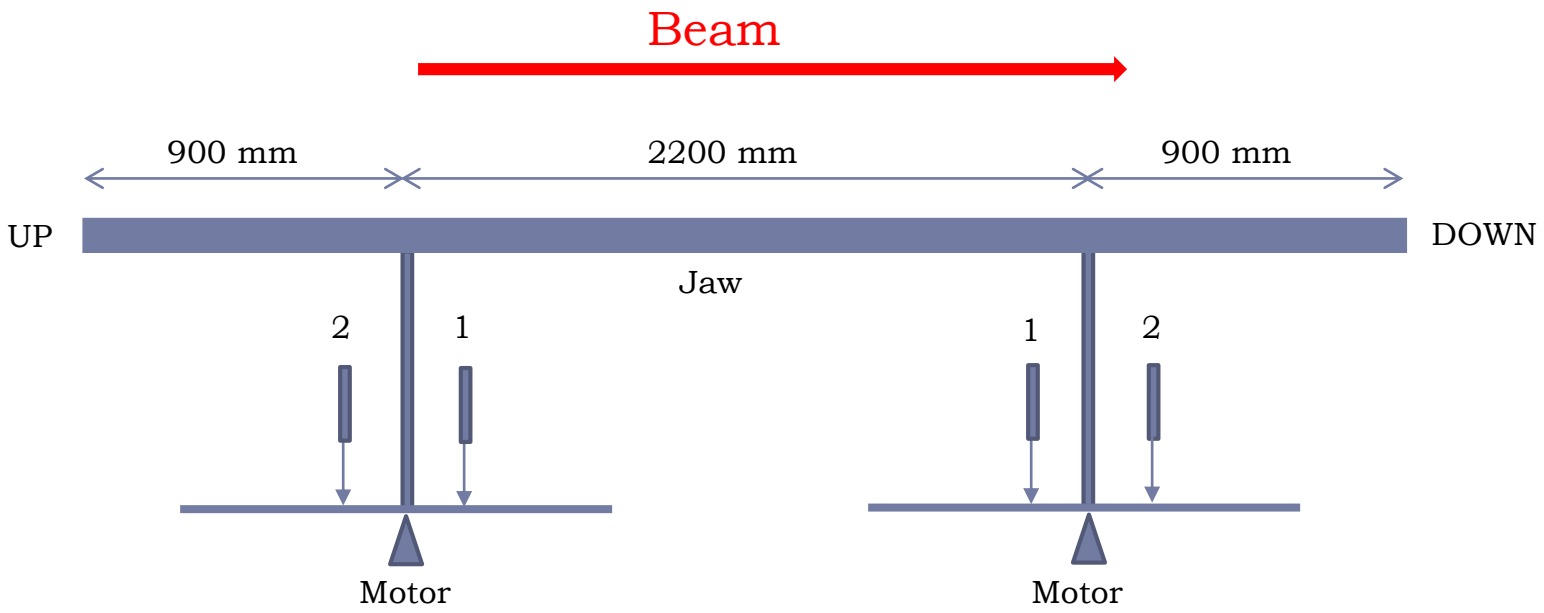
ABT/BTP
Acknowledgments: M. Barnes, M. Di Castro, E. Carlier, R. Losito, A. Masi.

Outline

- TDI
  - Heating
  - Issues encountered with TDI right jaw and resulting deformation
  - TDI checks
  - Followup and Improvements
- Scrubbing run:
  - TDI position and MKI/MKE interlocks

TDI Position Sensors: LVDT

- One LVDT on each side of the support bar allows to detect deformation



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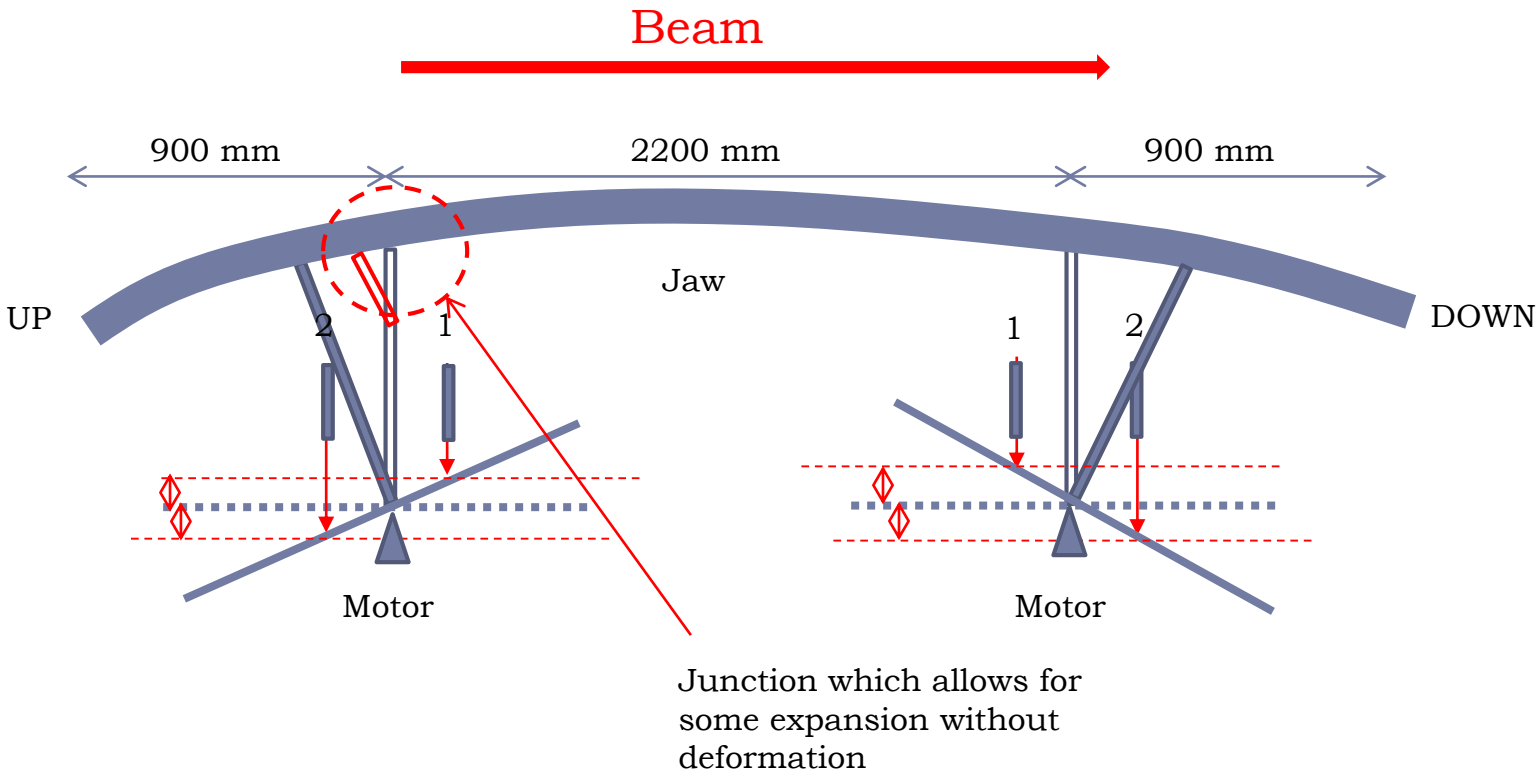
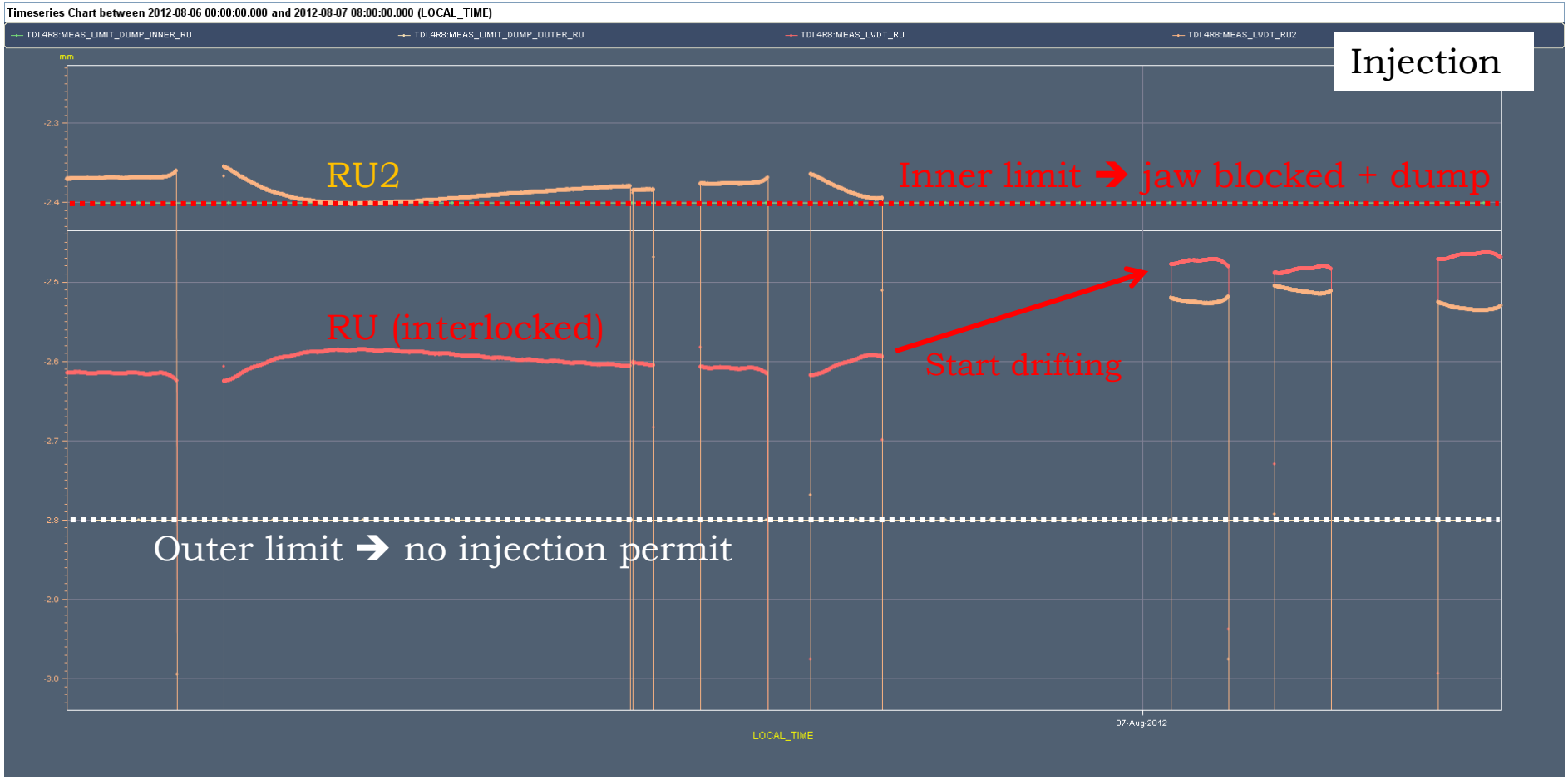
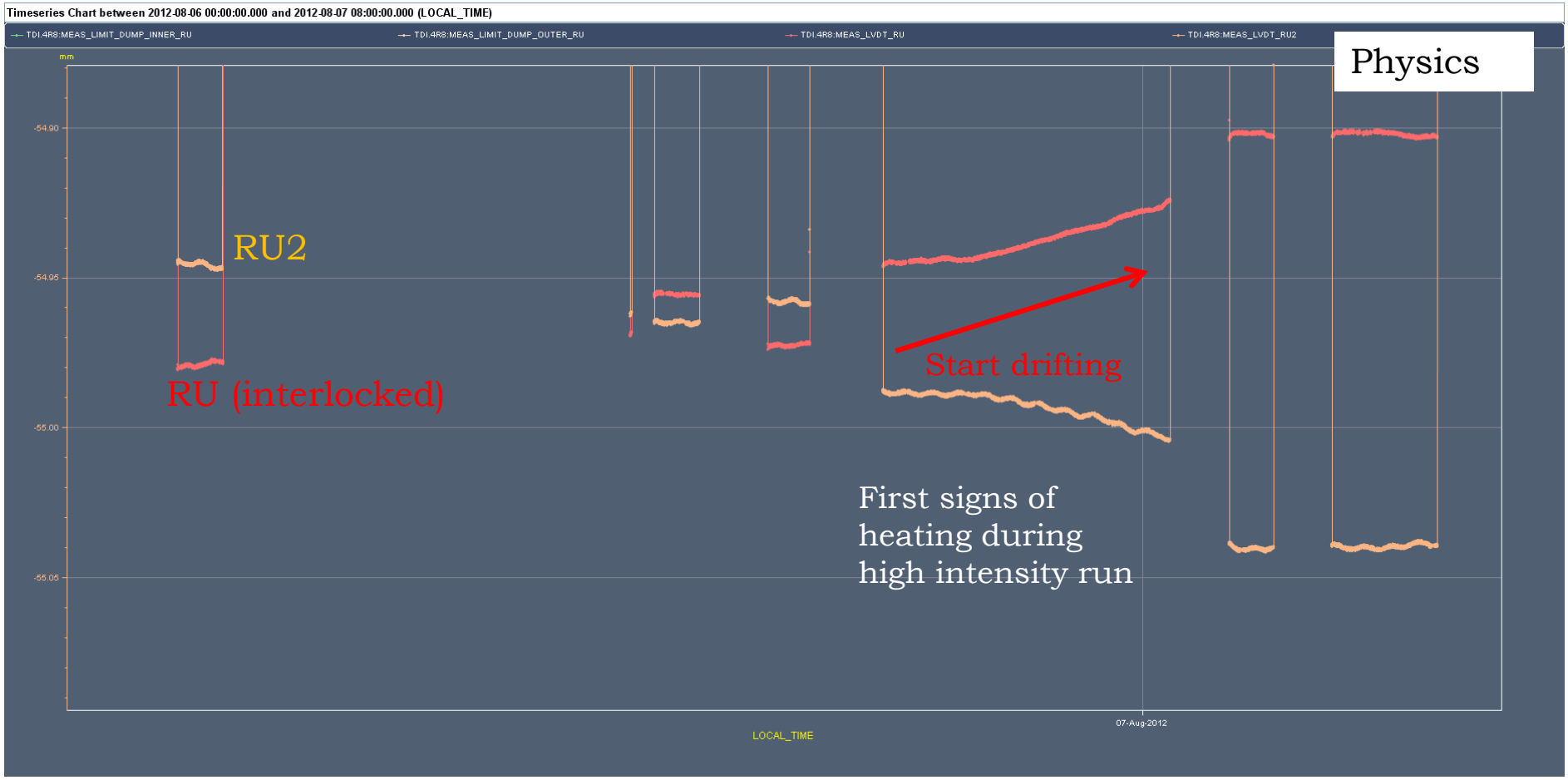


TDI Heating


Timeseries Chart between 2012-08-06 00:00:00.000 and 2012-08-07 08:00:00.000 (LOCAL_TIME)
TDI.4R8:MEAS_LIMIT_DUMP_INNER_RU
TDI.4R8:MEAS_LIMIT_DUMP_OUTER_RU
TDI.4R8:MEAS_LVDT_RU
TDI.4R8:MEAS_LVDT_RU2
mm
-2.3
-2.4
-2.5
-2.6
-2.7
-2.8
-2.9
-3.0
Injection
RU2
Inner limit ➔ jaw blocked + dump
RU (interlocked)
Start drifting
Outer limit ➔ no injection permit
07-Aug-2012
LOCAL_TIME

TDI Heating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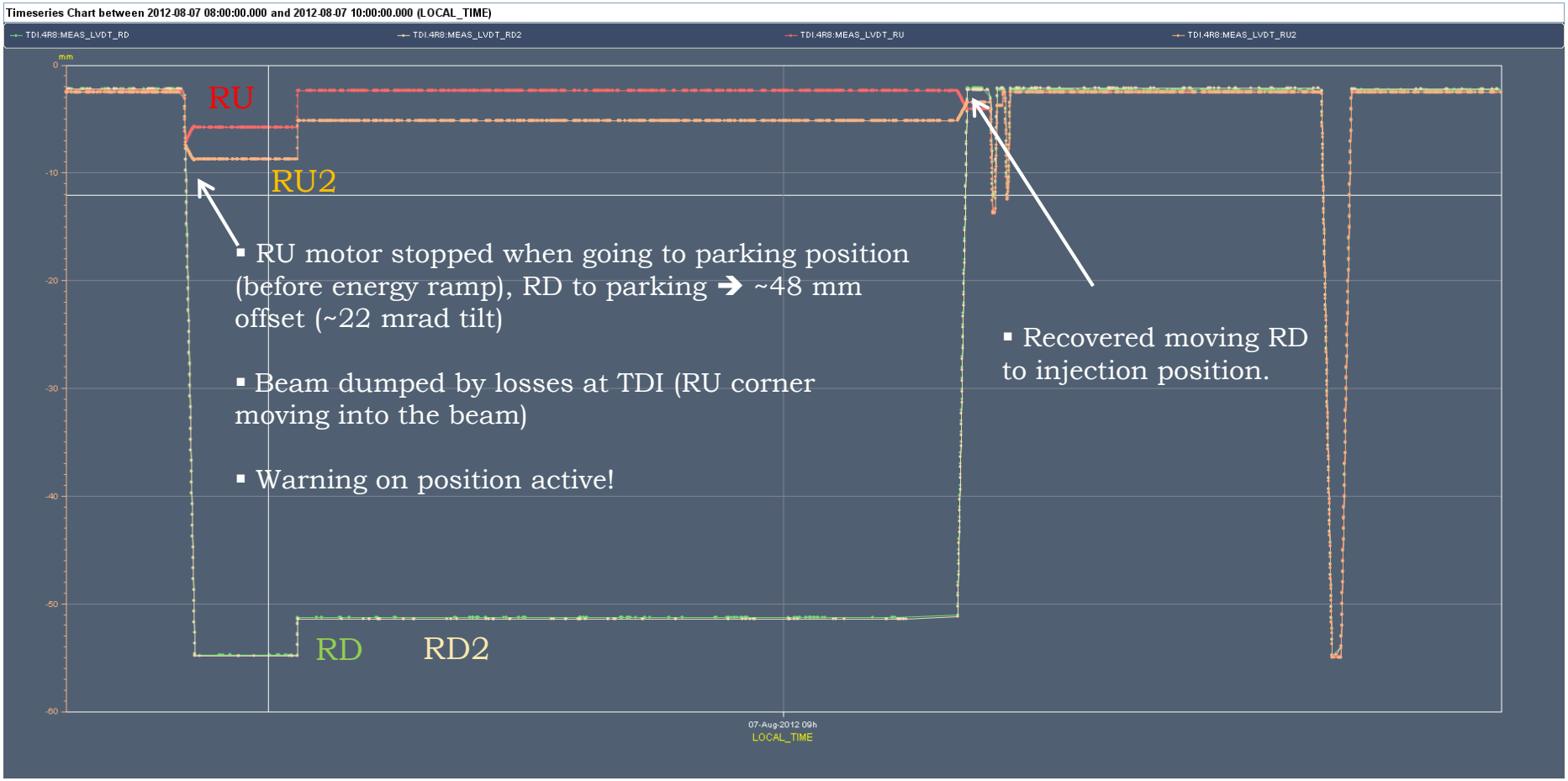
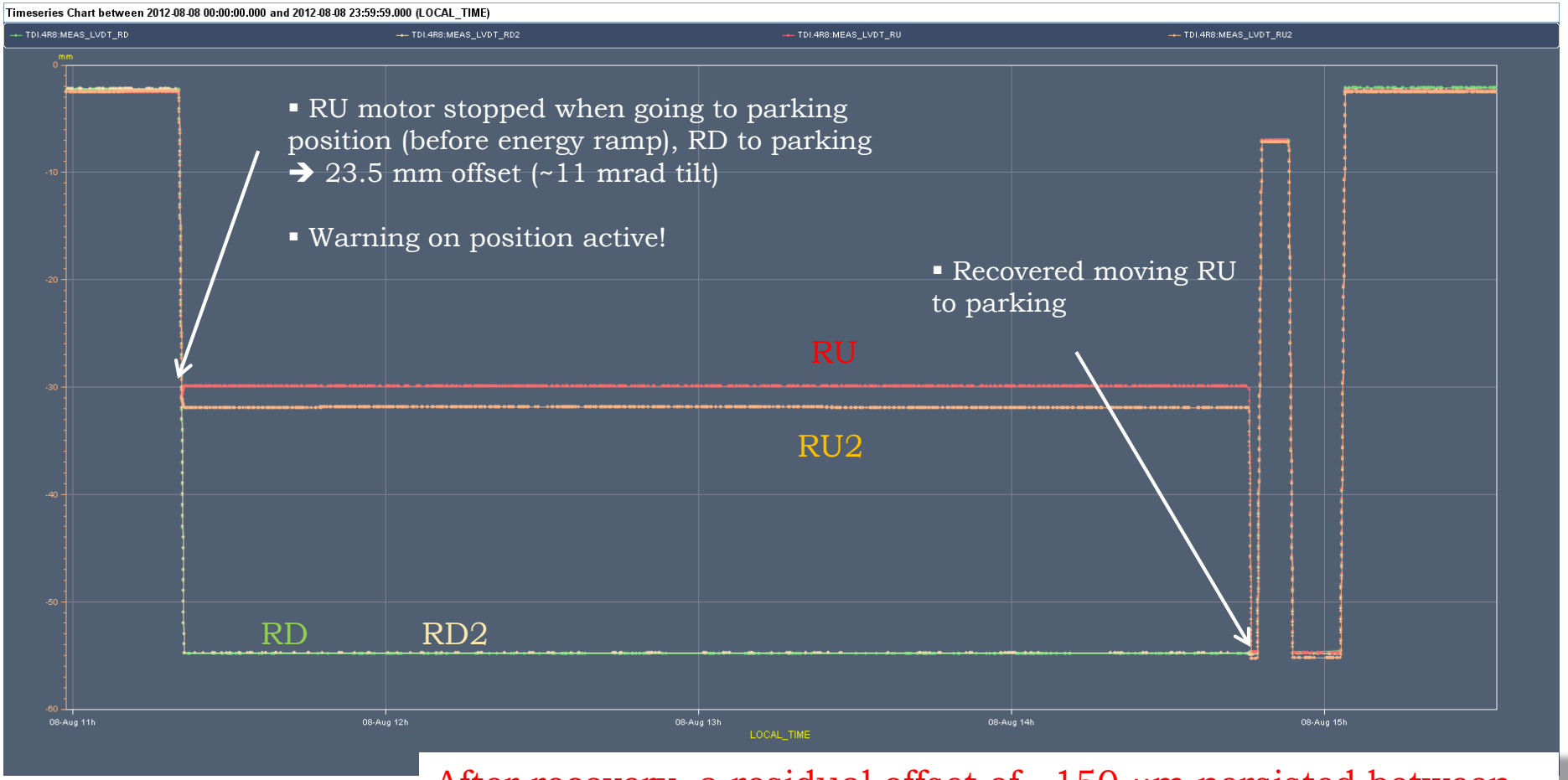
TDI.4R8:MEAS_LVDT_RU
TDI.4R8:MEAS_LVDT_RU2
mm
-54.90
-54.95
-55.00
-55.05
RU2
RU (interlocked)
Start drifting
First signs of heating during high intensity run
Physics
07-Aug-2012
LOCAL_TIME

TDI Issue 07/08/2012



TDI Issue 08/08/2012



After recovery, a residual offset of ~150 μm persisted between **RD LVDT** and **Resolver** at injection position ➔ deformation!

http://accelconf.web.cern.ch/accelconf/icalepcs2011/papers/wepmu020.pdf

M. Di Castro slides: \\cern.ch\dfs\Users\c\cbracco\Public\TDI 4R8_Skew_August 2012

Cause and Follow-up

Cause:

- **Not found any mechanical problem** ➔ not clear correlation with TDI heating
- Most likely candidate: **spurious glitch** on the RU end-switch ➔ switch active ➔ motor stopped

Follow-up:

- The **control module** (rack in service tunnel) of the switch was **exchanged** (09/08/2012) ➔ the problem did not appear any more
- New task in the sequencer: **TDI position check before ramp.**

Switch Exchange and Re-initialisation

- After switch exchange the motor counter had to be re-initialised ➔ LVDT used as reference
  - Parking position used as reference (09/08/2012), moreover 150 µm offset introduced by the deformation ➔ interlocked LVDT too close to inner dump threshold at injection position

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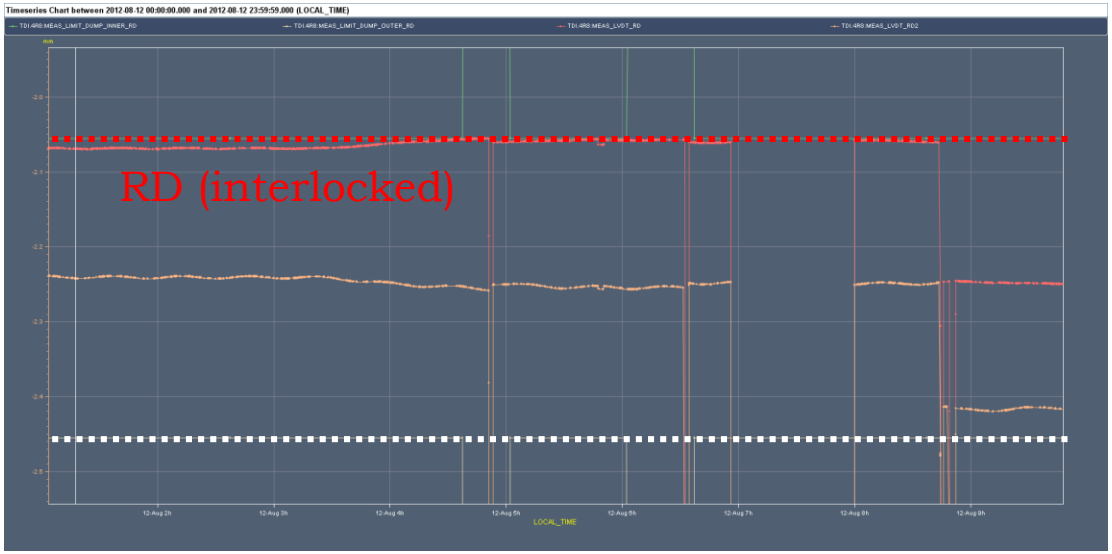

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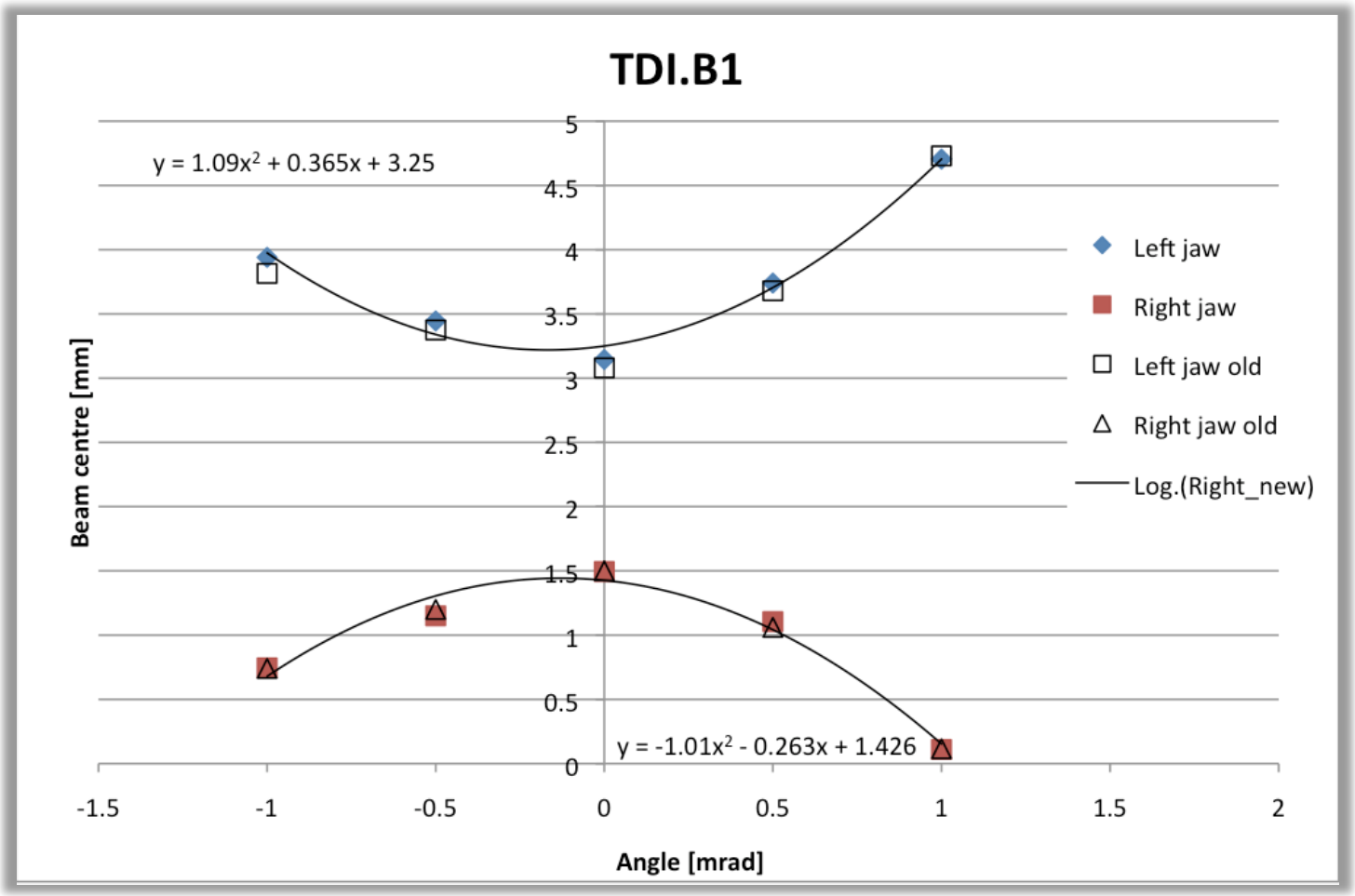
  - Beam dumped during Q20 injection studies because of thermal drift (12/08/2012).
  - New re-initialisation: offset “removed” using as reference an old LVDT reading at injection position (before 07/08/2012) ➔ centered wrt thresholds **BUT 150 μm deformation hidden by the new re-initialisation**! **Impact on the jaw?**

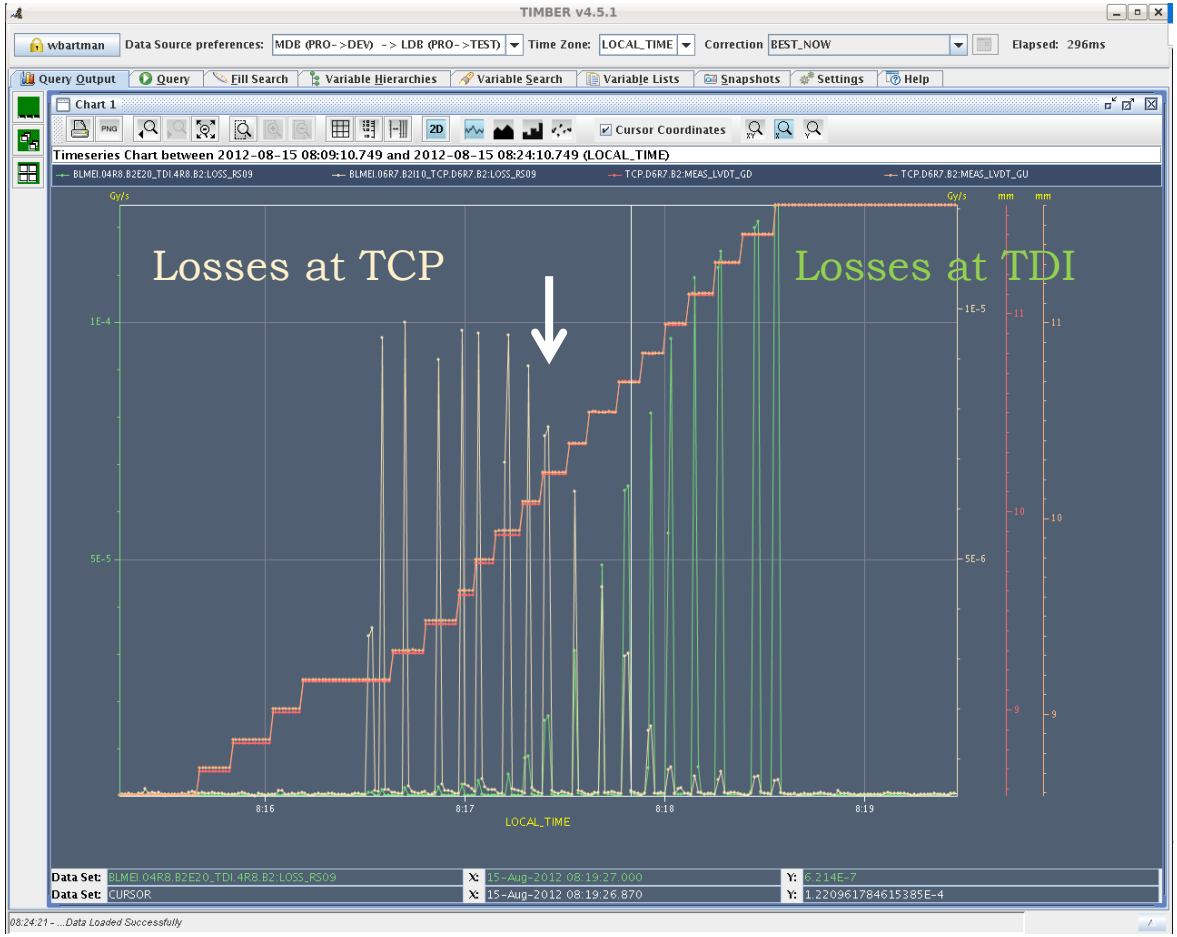
TDI Setup Checks

- Angular scan ➔ no measurable change



TDI Setup Checks

- Retraction wrt vertical primary collimator: beam blowup with MKQ ➔ retract TCP with 0.1 sigma (76 μm) steps ➔ TDI becomes primary when losses decrease at TCP and increase at TDI ➔ number of TCP steps gives retraction



Nominal retraction = 6.8 σ

Measured retraction:
Right jaw = 6.8 ± 0.1 σ
Left jaw = 6.4 ± 0.1 σ

Old measurements:
Right jaw = 6.6 ± 0.1 σ
Left jaw = 6.4 ± 0.1 σ

Difference within the measurement accuracy.

TDI jaws OK!

Future Improvement (TS3)

Modify the low level (PXI) control software to introduce a check on the skew angle of the TDI jaws:

- **Check** the **command sent from the operator** (sequencer) to verify that the **requested position is within the admissible angle**. The command will be **refused** in case the angle is too big and a **warning** will be sent back.

- Add a **control on the position** measured with the **resolvers** to ensure that during a movement a jaw cannot go into a dangerous state. Also in this case **no dump**, but just a **warning** sent back to the operator, and the **two motors of that jaw will be stopped**.

- **Maximum allowable skew angle**: **5 mrad** (11 mm offset between up and downstream LVDT)

Scrubbing Run with 25 ns beam 4/10-8/10

- Scrubbing run:
  - Injection and accumulation of trains of 144-288 bunches
  - Long periods without injections
  - The TDI has to be retracted to parking position if staying >*15 minutes (?)* without injections to limit heating/deformation

Risk of MKI erratics with TDI retracted ???

MKI interlocks : "NO-TRIGGER PULSE" the **PFN** gets **discharged** through the **dump switch ~2.5 ms after the injection pre-pulse**

TDI interlocks: injection inhibit if TDI jaws open to parking (BIS) ➔ **no beam permit➔ inhibit the pre-pulse triggers and not possible to charge the MKI PFN ➔ no erratics**

Risk of extraction from SPS with TDI retracted ???

MKE interlocks: "NO-TRIGGER PULSE" only in point 4. No dump switch in point 6 but **No beam permit** if **TDI open** (injection permit removes the extraction permit.). Only possible to extract if **TED in.**

Further protection: Dedicated sequence to put MKI into STANBY before moving the TDI out (Injection permit removed when MKI in STANDBY).

Conclusions

- A problem with TDI right jaw occurred twice at the beginning of August
  - Spurious glitch at end-switch ➔ upstream corner blocked when moving to parking ➔ big tilt and residual deformation
  - Task added in the sequencer to check TDI jaw position wrt settings before the energy ramp
  - Switch control module exchanged ➔ no more problems up to now
  - TDI jaw checked with beam and no measurable effects on angle and retraction wrt TCP
  - Further improvements will be applied at the low level control during TS3
- Sign of heating inducing LVDT drifts observed when moving to high bunch intensity ➔ elastic deformation
- Scrubbing run:
  - TDI retracted to parking if > 15 minutes without injections
  - Dedicated sequence to put MKI in STANDBY before moving TDI
  - “No-trigger pulse” prevents MKI and MKE4 pulses 2.5 ms after injection pre-pulse (MKE6 relays on no beam permit with TDI open)
  - TDI open ➔ no beam permit ➔ no erratics
  - Future upgrade (LS1): add TDI jaw position in to MKI BETS.