LBDS System Re-commissioning

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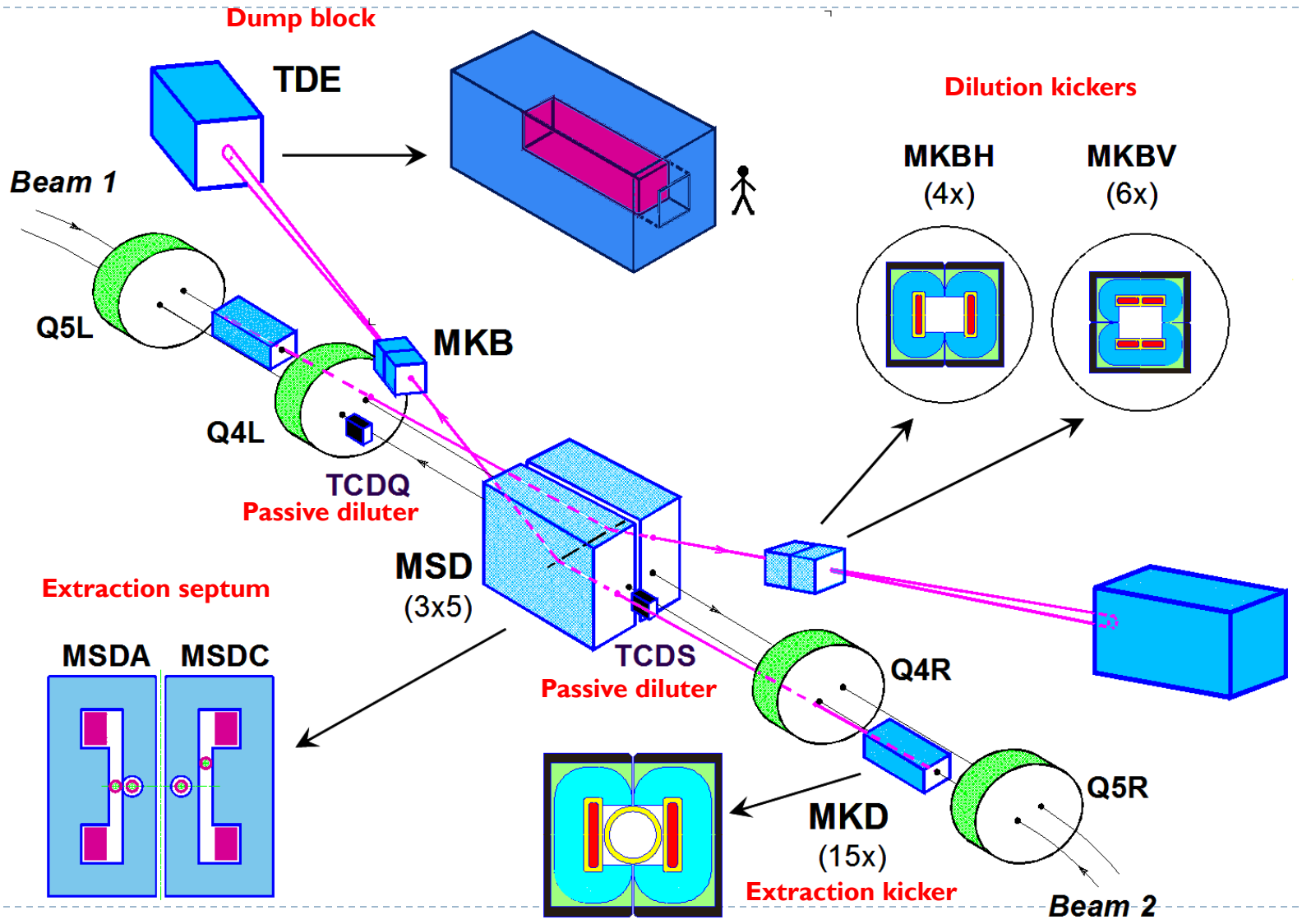
Acknowledgments: collimation team

Outline

- System Overview
- Recap of standard commissioning procedures
- Changes/upgrade during LS1 for operation at 6.5 TeV with 25 ns beam:
  - List of topics (future talks)
  - Details of new procedures for TCDQ/TCSP

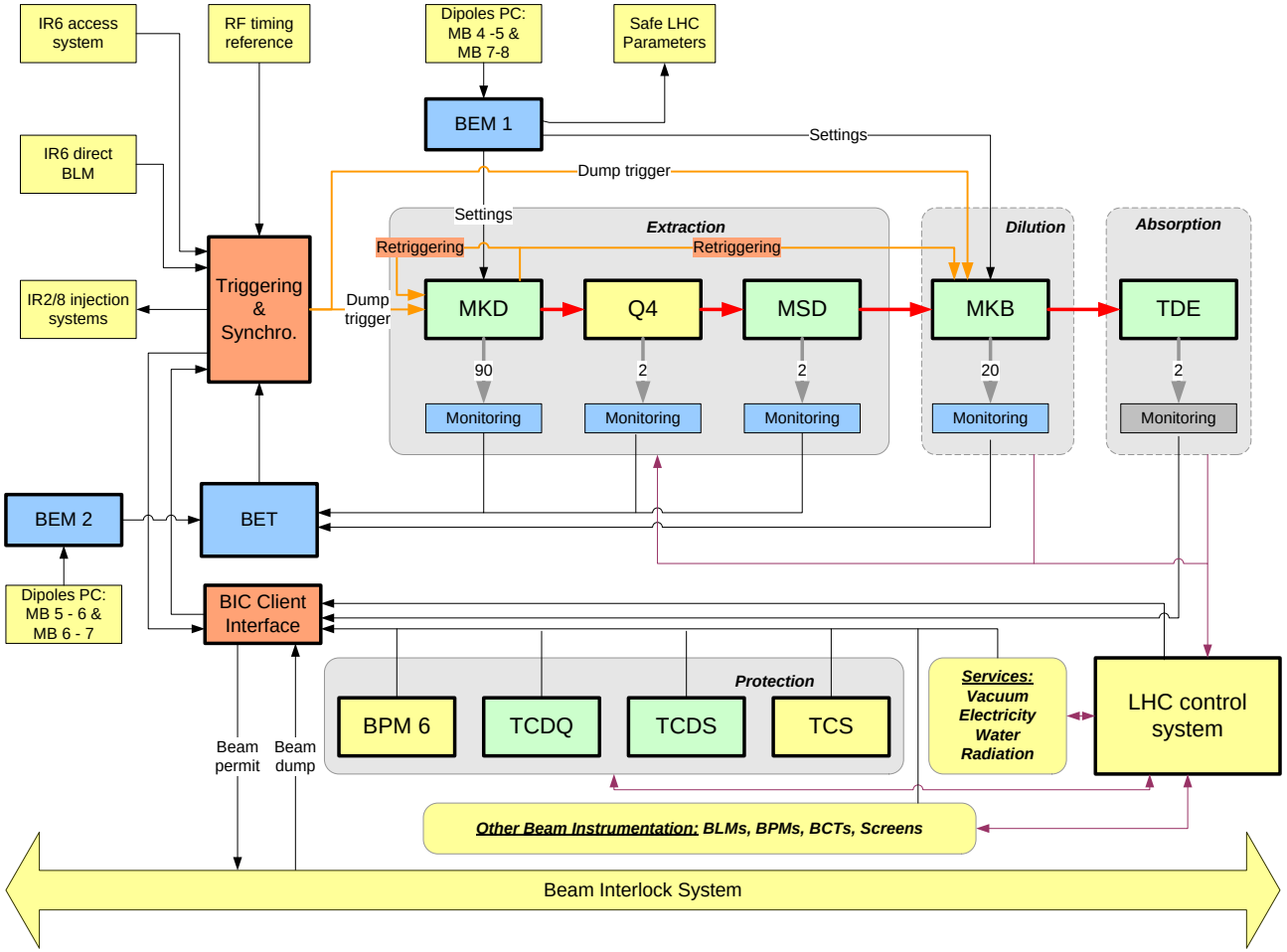
LHC beam dump overview (and acronyms)



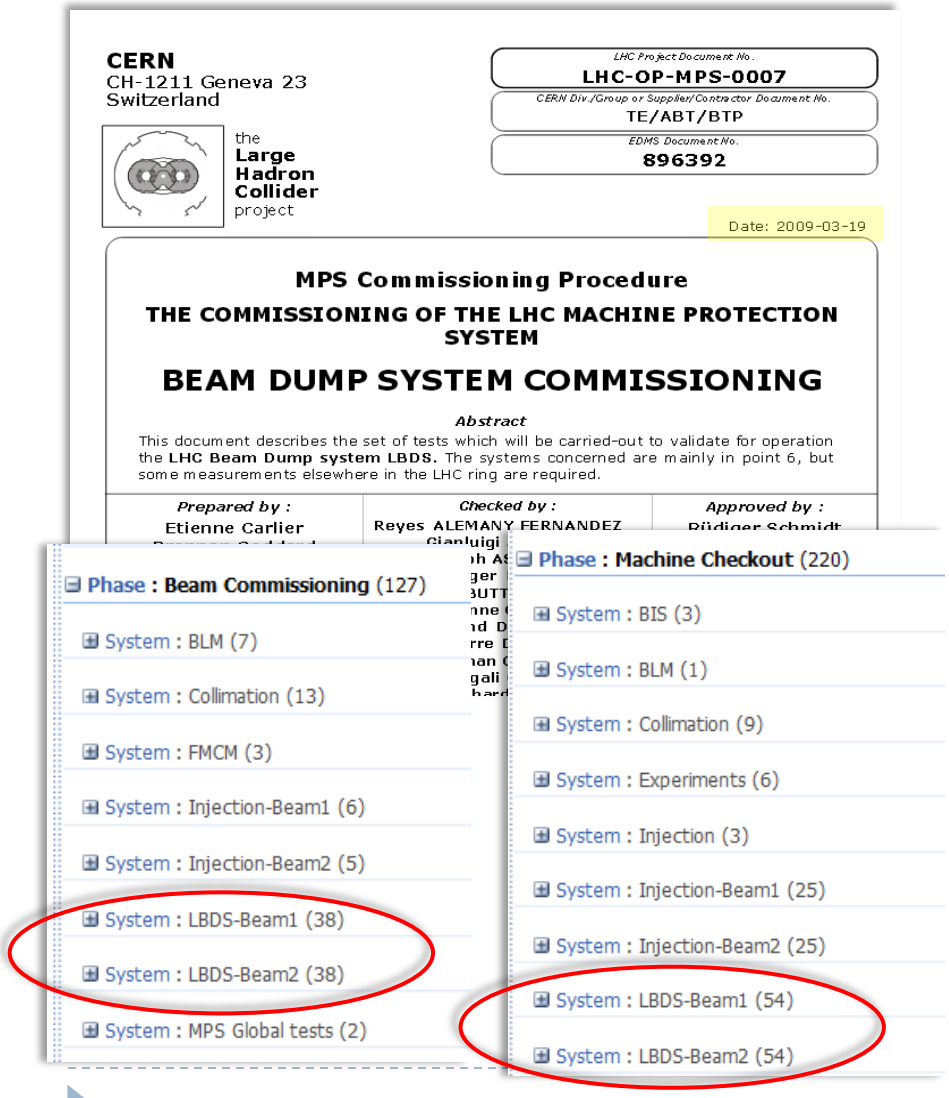
Main subsystems and acronyms

- *15 extraction kickers MKD*
- *15 extraction septa MSD*
- ***10 (last 2 installed during LS1)** dilution kickers MKB*
- *Dump block TDE (slight overpressure of N_2)*
- *Protection devices TCDS, TCDQ, TCSG → TCSP*
- Vacuum lines TD
- Beam instrumentation BPM, BLM, BTV, BCT, BLMPS (direct BLM), abort gap monitor and cleaning
- Triggering and synchronization unit TSU
- Beam energy tracking system BETS
- Post operational checks IPOC, XPOC

LBDS Functional Dependencies



MPS Commissioning Procedure



Long list of all procedures for tests with and without beam (kickers, sequencer, timing, BIS, links to injection system, XPOC, IPOC, critical settings, BETS, TCDQ, Vacuum , diagnostics, link to access system, powering, interlocks, synchronization, abort gap monitor/cleaning, etc…).

- All these tests will be repeated
- Some procedures have to be modified
- New procedures have to be defined

Different more detailed documents with procedures for different systems?

LS1 Changes and Needed Updates

- LBDS **powering system**
- **TSU** upgrade
- **Re-triggering from BIS**

N. Magnin talk, Annecy MP workshop: https://indico.cern.ch/event/227895/session/4/contribution/19/material/slides/0.pptx

- Abort gap cleaning **interlock**: testing the interplay between BSRA, SIS, ADT and GUI to change cleaning strength. Evaluate the effect of the cleaning on emittance and/or luminosity.
- **Additional IPOC functionality**: now it includes all the generator signals.
- **New TCDQ** and **connection** to **BETS**
- **TCSP** (TCSG in IR6 with embedded **BPM**)

Update procedures for:

- **XPOC** modules on TSU signals were not in place in 2009 so testing will need to be added. Also testing of other XPOC modules to be updated, including the reset rights by OP and EXPERT. Increased BLM data samples…
- Direct BLM (directly triggering the dump system, no connection to BIS)
- MKD rise-time (how to measure it?)
- …..

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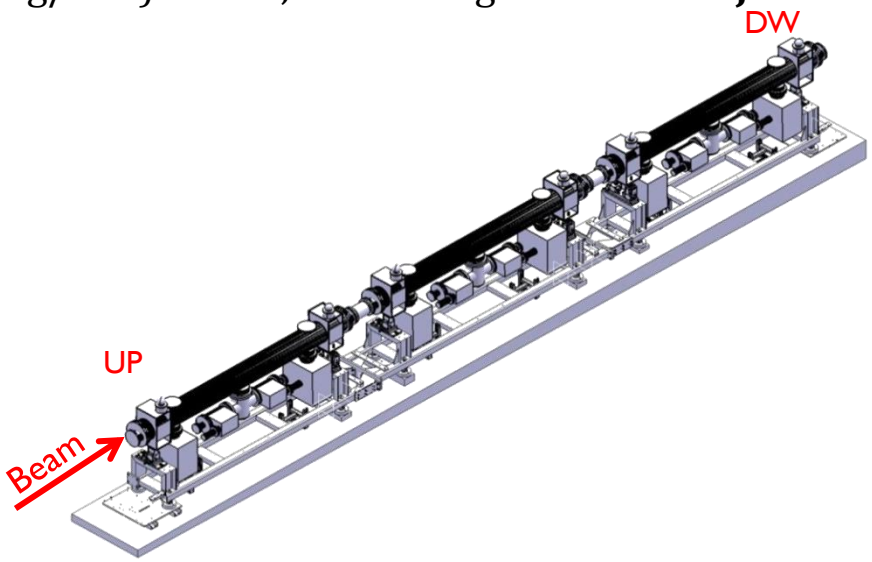
TCDQ New HW

New HW: 3 CFC (different density 1.75 g/cm^3 and 1.4 g/cm^3) blocks, ~3 m long each ➔ **9 m jaw**
Mandatory angular adjustment!

Assuming 100 μrad angle:

Energy [TeV]	β_x [m]	Emittance [m rad]	1 sigma [mm]	Offset UP-DW 6m jaw [sigma]	Offset UP-DW 9m jaw [sigma]
0.45	500	7.23E-09	1.901	0.3	0.5
4	500	8.21E-10	0.641	**0.9***	**1.4**
6.5	500	5.05E-10	0.502	1.2	**1.8**



* During "run 1", mechanical limit ±0.2 mrad
(not possible checking accurately the angular alignment)

Now: mechanical limit: ±1 mrad ➔ angular alignment with beam possible!!
Requirements: ±0.15 mm (~0.5 sigma @ 6.5 TeV) ➔ ~ **±30 μrad**

Same procedure as for TDI

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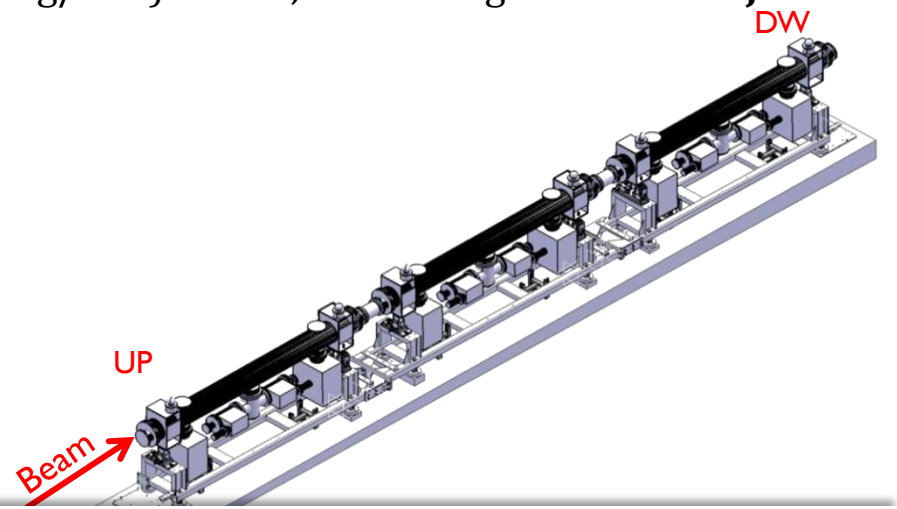

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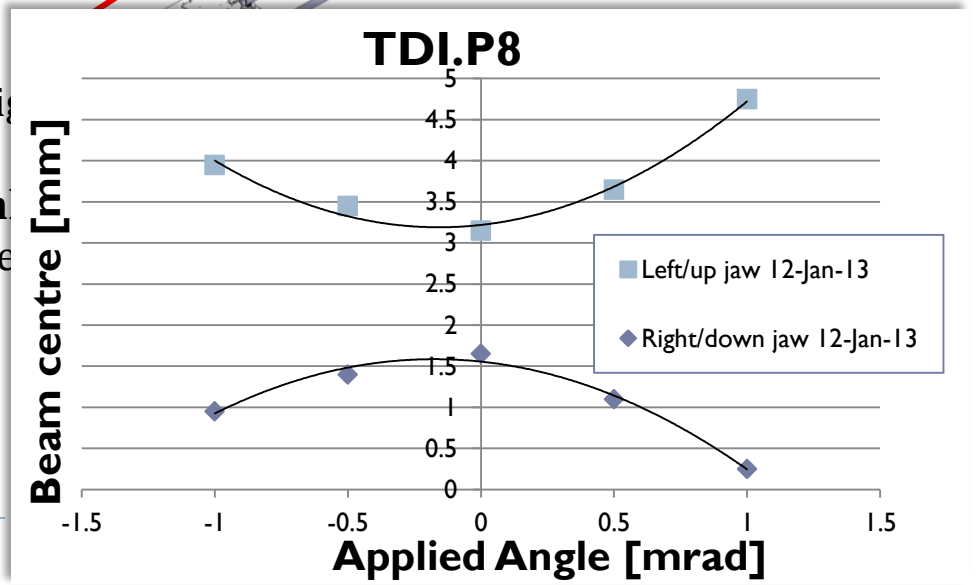


TCDQ Connection to BETS

- **TCDQ** connected to the **BETS** for **redundant measurement/check** : interlock on **absolute position** (single-sided collimator) depending on **beam energy** (the transfer function will map the beam position to an energy value)

- Present interlocks are at ±0.25sigma , while the BETS will interlock at **±0.35 sigma** (independent interlock!).

- Testing procedure (without beam, machine closed):
  - Fix energy, relax collimation interlocks (i.e. ±1 sigma) ➔ move TCDQ outside BETS limits ➔ check BIS to FALSE ➔ beam dump request
  - Ramp magnets and run collimator functions ➔ Check everything fine if TCDQ inside limit

New Procedure

- Operation at 6.5 TeV with 25 ns beams ➔ in case of **"real" asynchronous beam dump** we will need to **check possible damage of the TCDQ/TCSP.**

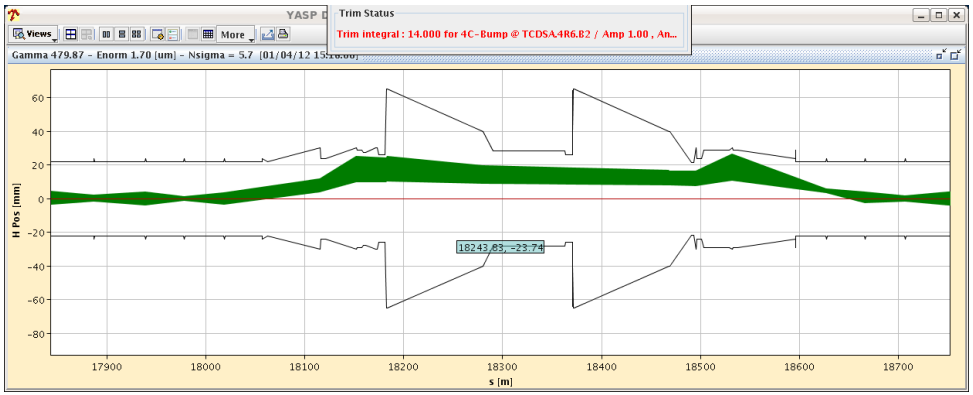
- A procedure has been worked out and relies on calibration measurements to be performed during re-commissioning and to be used as **reference**.
  - HW checks and local inspection
  - Measurements with beam:
    - Aperture measurements
    - Standard asynchronous beam dump check ➔ comparison of loss patterns
    - Transmission measurements

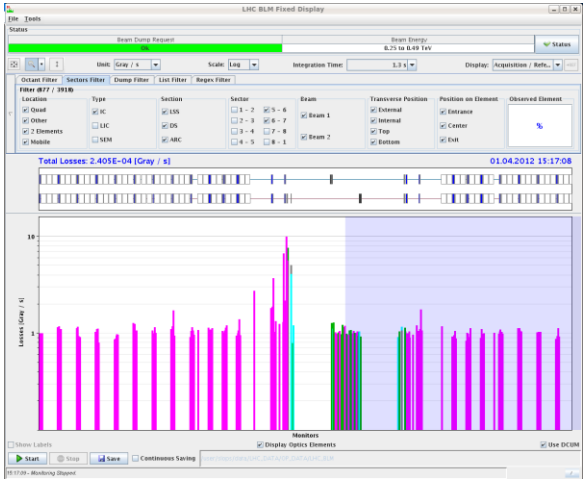
HW Checks and Local Inspection

- Cooling water connections and feed-through
- Jaw movements and sensor response
- Vacuum bellows
- **Local activation** on diluters and downstream elements (a **reference measurement following regular operation** is needed)
- **Vacuum pressure** during jaw movements (no changes should be apparent, **reference measurement** needed)

Measurements with Beam

- Reference aperture measurement at the diluters:
  - Orbit corrected, interlocks masked (BPMs, collimator thresholds open)
  - **Aperture scans** with circulating beam (pilot) with TCDQ/TCSP **IN** (injection position) and **OUT** (parking position):
    - Beam moved in steps (1 sigma) towards jaw and record losses at TCDQ, TCSP, TCDQM, Q4, TCTs (TCP.IR7 @ 5.7 sigma defines beam envelope, MKQ used to blow up the beam up to 5.7 sigma)
    - Repeat moving beam to other direction
    - Define a reference loss pattern

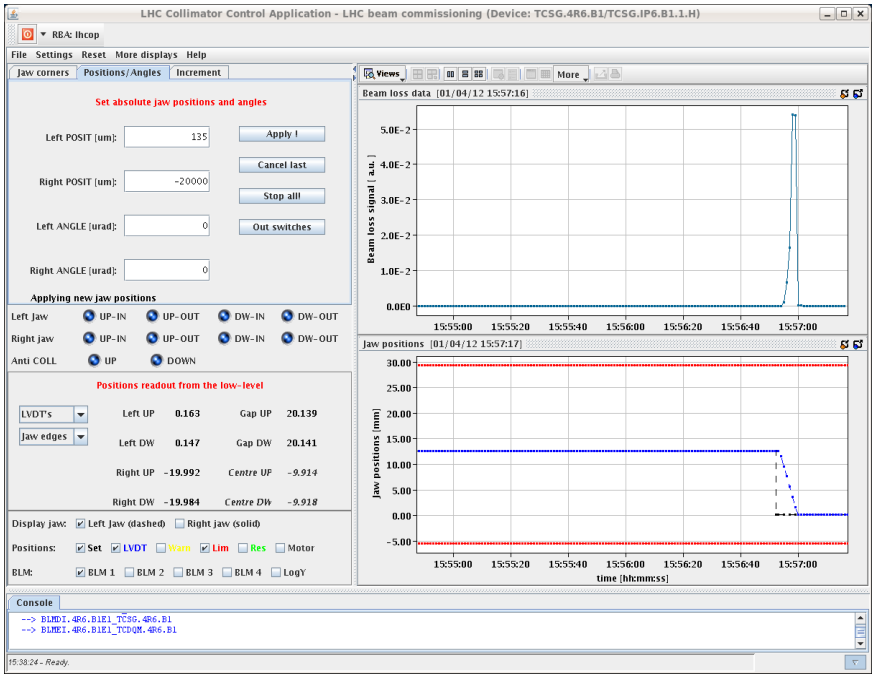


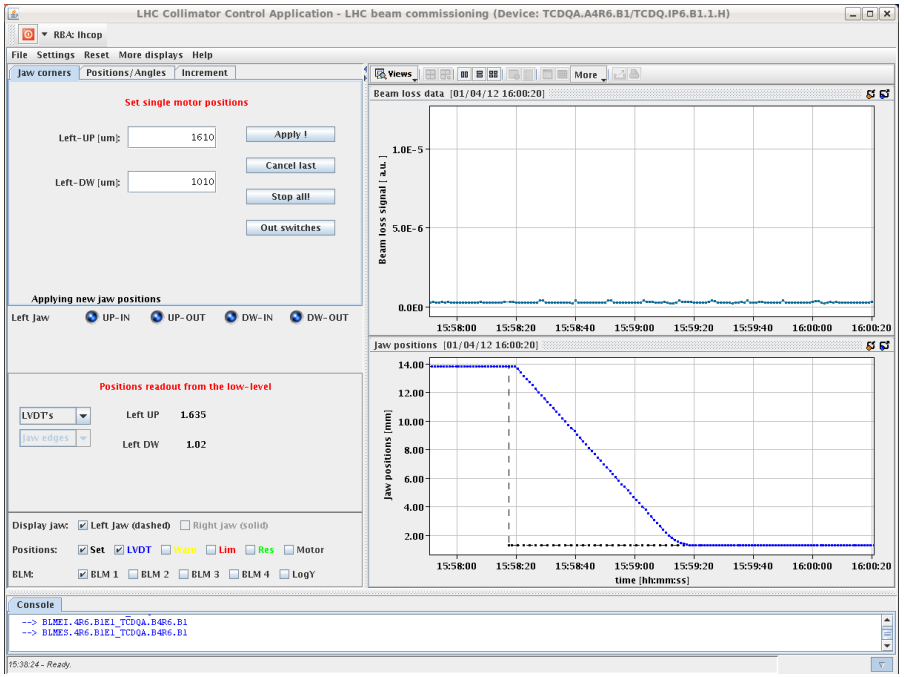


- In case of asynchronous beam dump with given beam intensity, repeat the test and check that no unexpected losses appear ➔ no unforeseen obstacles sticking into the beam

Transmission Measurements

- TCDQ and TCSG closed (TCSG left jaw at collimator centre, TCDQ jaw retracted by 1 sigma)





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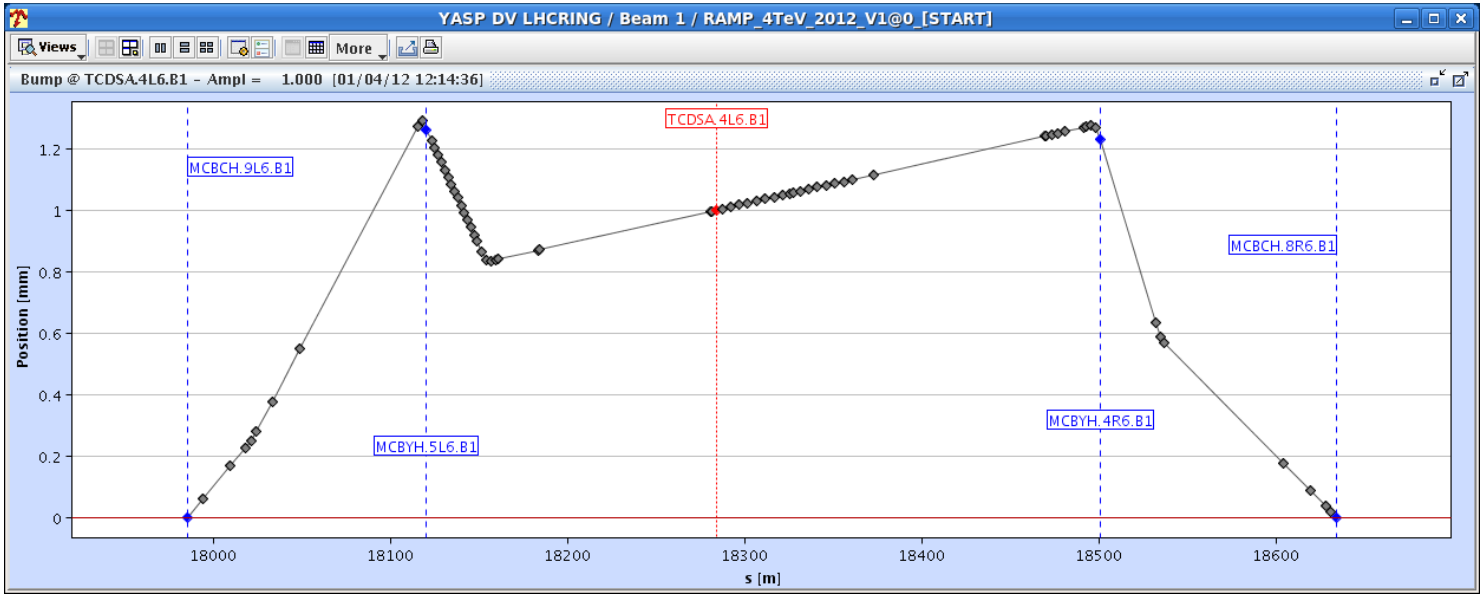
- Bump at TCDQ (the one used for asynchronous dump tests but in direction of the jaw)



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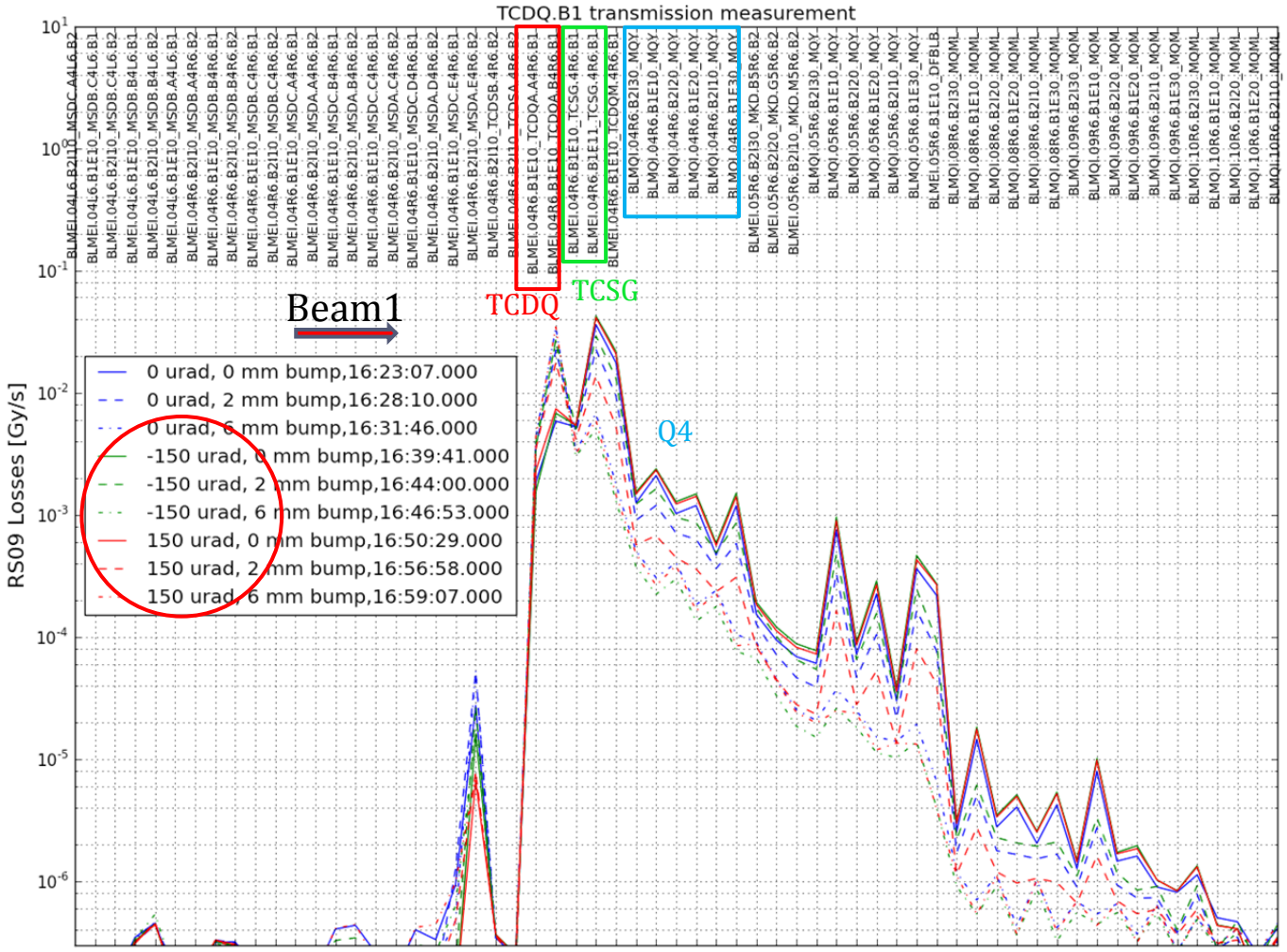
- Bump at TCDQ (the one used for asynchronous dump tests but in direction of the jaw)
- I&D 1 turn with probe beam
- Inject with bump amplitudes of 0, 2 and 6 mm for TCDQ angles of 0 and ±1 mrad (possibly intermediate angles) around actual position ➔ check loss pattern

Results from 2012 Tests (6 m long TCDQ)



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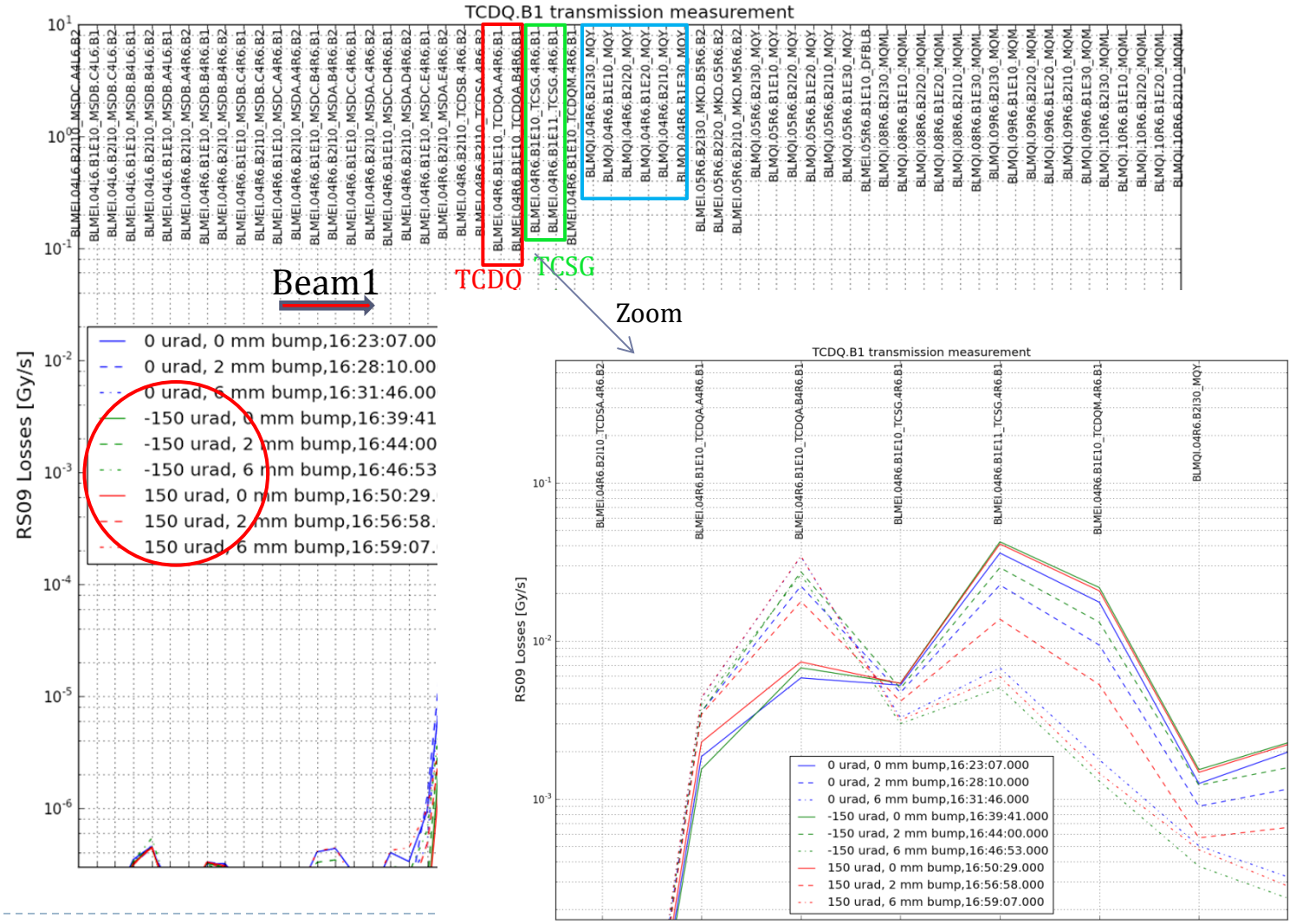

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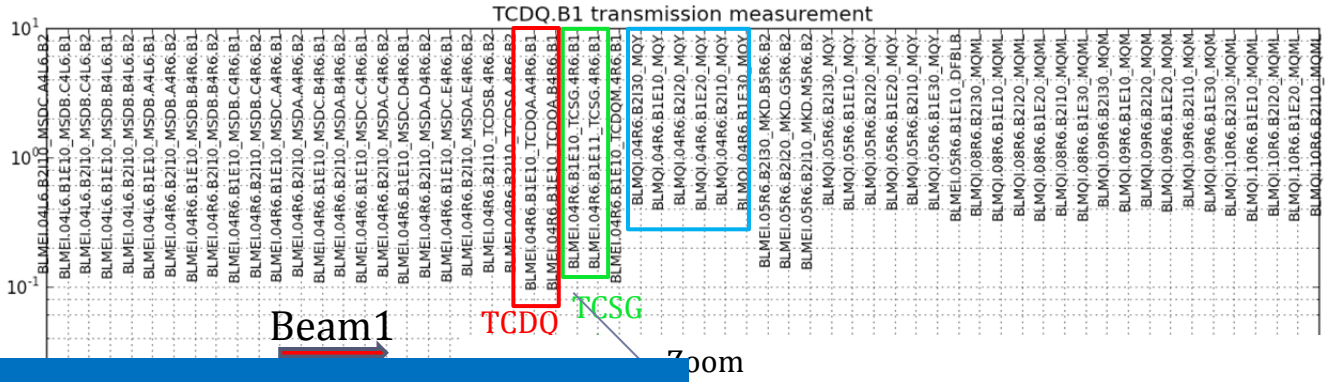
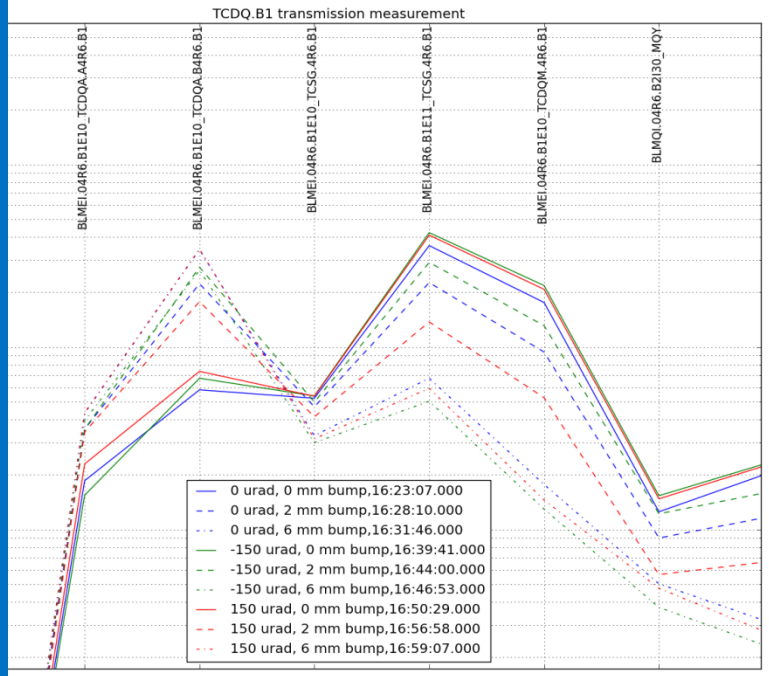


Results:

- with 0 mm bump the highest losses are at the TCSG
- with 2 mm bump loss peaks similar between TCDQ and TCSG
- with 6 mm beam is completely dumped at the TCDQ (calibration of secondary showers from TCDQ to TCSG on Q4)
- In case of ABD ➔repeat and check that ratio between losses at TCDQ/TCSP and Q4 doesn't change



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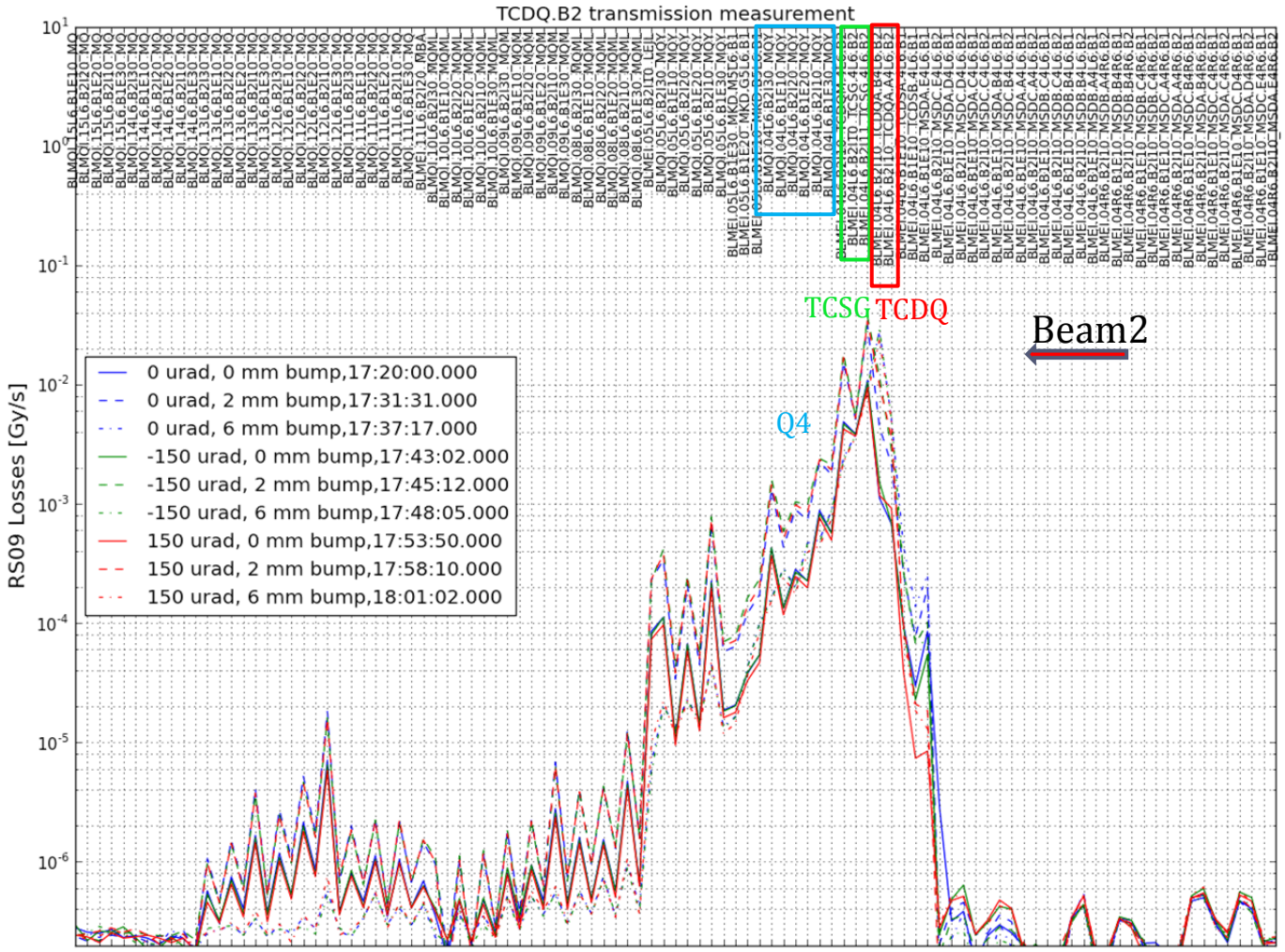

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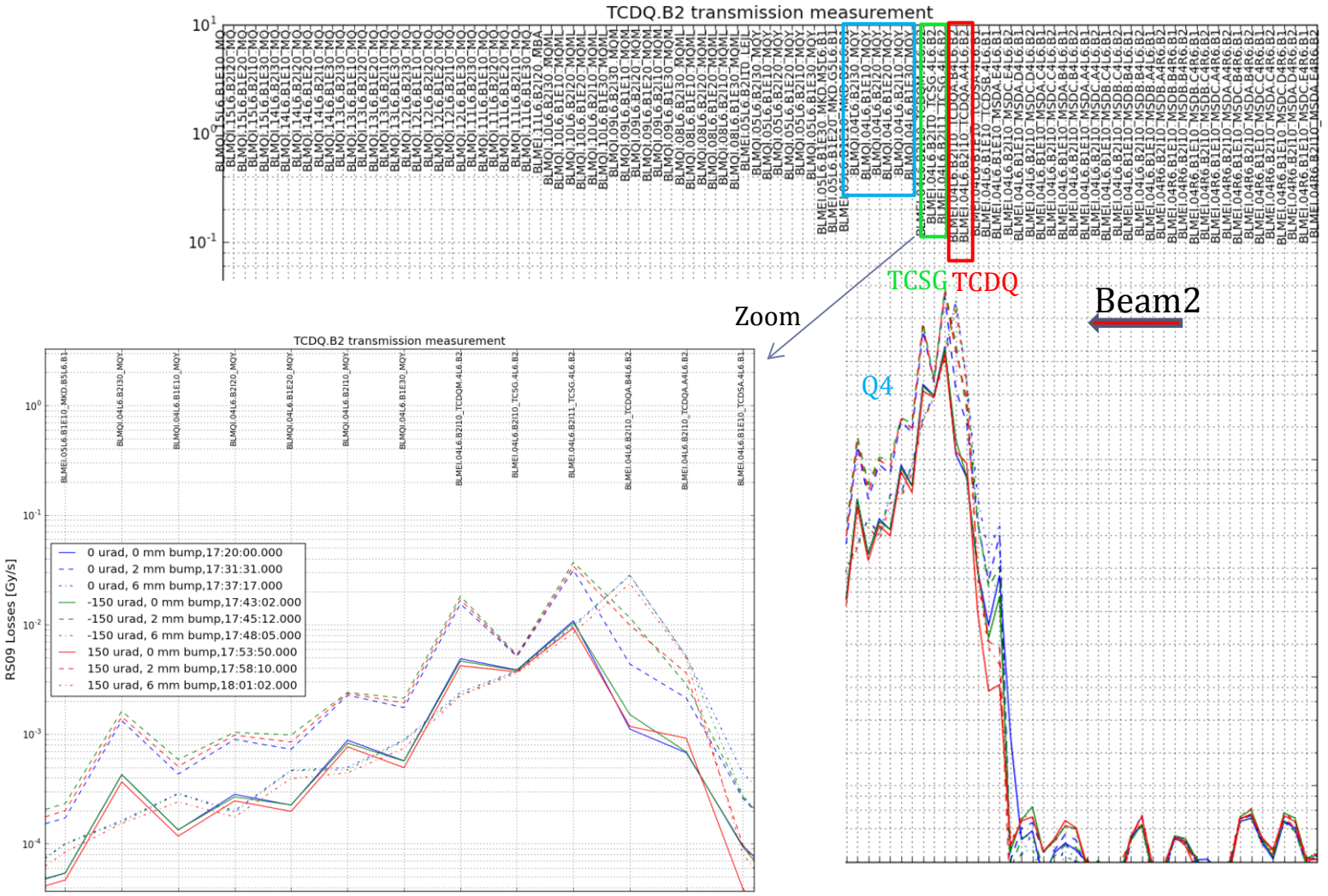
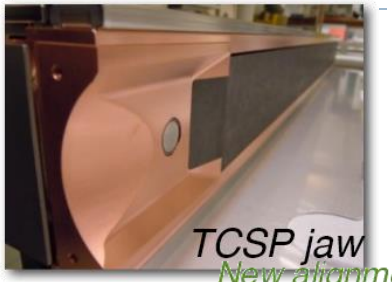


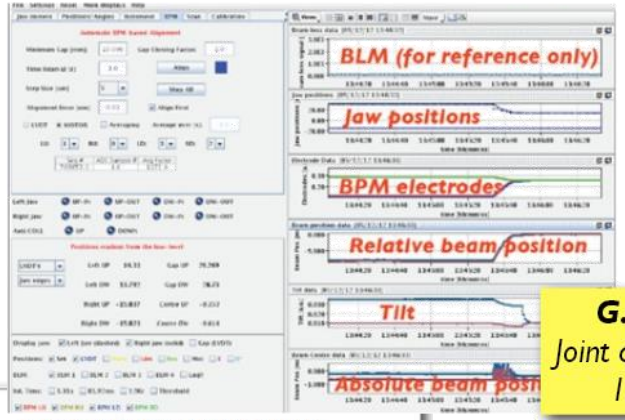
TCSP Commissioning

- TCSG in IR6 exchanged with TCSP: secondary collimator with BPM
- New beam based alignment procedure and GUI (G. Valentino)
- Collimation team performing surface tests with stretched wires
- Standard Machine Protection tests performed in collaboration with collimation team
- Beam based alignment and validation: loss maps and ADB test (collimation and BTP team)
- Option of using the **BPMs** reading in **XPOC** taken into account (implementation and checks)

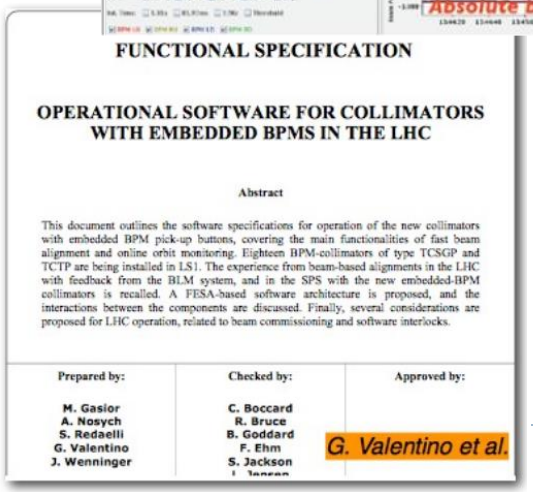


B. Salvachua
LBOC 25/02/2014

New alignment GUI and fixed display



G.Valentino
Joint controls meeting
10/02/2014



FUNCTIONAL SPECIFICATION

OPERATIONAL SOFTWARE FOR COLLIMATORS WITH EMBEDDED BPMS IN THE LHC

Abstract

This document outlines the software specifications for operation of the new collimators with embedded BPM pick-up buttons, covering the main functionalities of fast beam alignment and online orbit monitoring. Eighteen BPM-collimators of type TCSGP and TCTP are being installed in LS1. The experience from beam-based alignments in the LHC with feedback from the BLM system, and in the SPS with the new embedded-BPM collimators is recalled. A FESA-based software architecture is proposed, and the interactions between the components are discussed. Finally, several considerations are proposed for LHC operation, related to beam commissioning and software interlocks.

Prepared by:	Checked by:	Approved by:
M. Gasior A. Nosych S. Redaelli G. Valentino J. Wenninger	C. Boccard R. Bruce B. Goddard F. Ehm S. Jackson	G. Valentino et al.

Summary

- The LBDS is a complex system relying on many critical subsystems and interfacing directly with several other LHC systems
- A detailed list of MP procedures w/wo beam, for all the subsystems, was published in 2009 (EDM N. 896392) ➔ in total 54 tests for machine check out and 38 tests for commissioning with beam
- All the tests in the procedure will have to be repeated after LS1
- Some procedures will have to be updated and new tests have to be defined following the changes/upgrades applied during LS1 (work ongoing)
- Revised procedures for the new 9m long TCDQ (angular alignment, BETS interlock, reference measurements for ABD) have been presented and will be documented in a detailed EDMS note.
- Commissioning and setup procedures for TCSP with BPMs have been shown (collimation team)
- Updates on procedures for other subsystems will be presented in the following MPP
- Due to the complexity of the system, the option of producing separate documents with detailed procedures for defined subsystems and/or dedicated tests has to be evaluated (powering tests, XPOC/IPOC checks, machine checkouts and tests with beam) .