Controlled Transverse Blowup with ADT from first tests in 2011 to plans for Quench Margin tests

presented by
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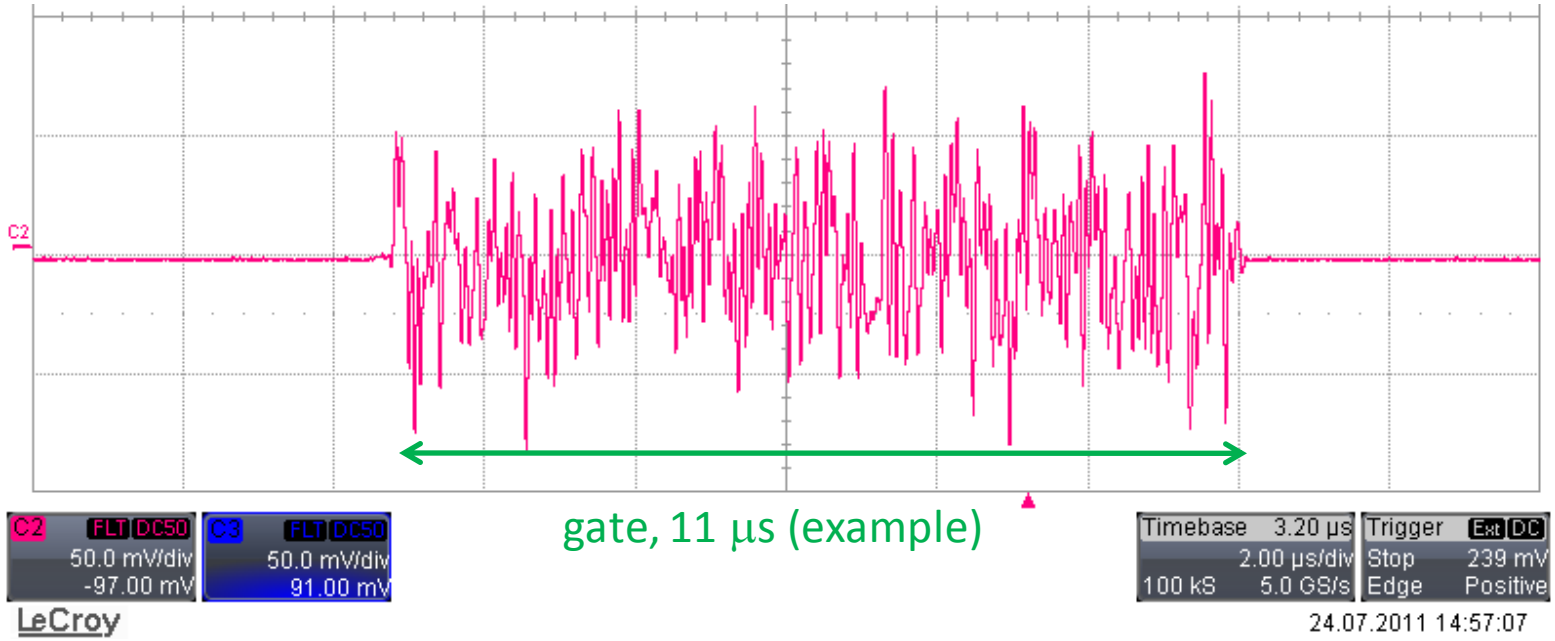
Motivation for transverse blow-up using ADT

- efficient loss maps
- tailoring emittances for special MDs
- probing aperture
- Quench Margin tests
- …

Method: apply excitation with gated noise

(D. Valuch, M. Jaussi, D. Jacquet, T. Levens)

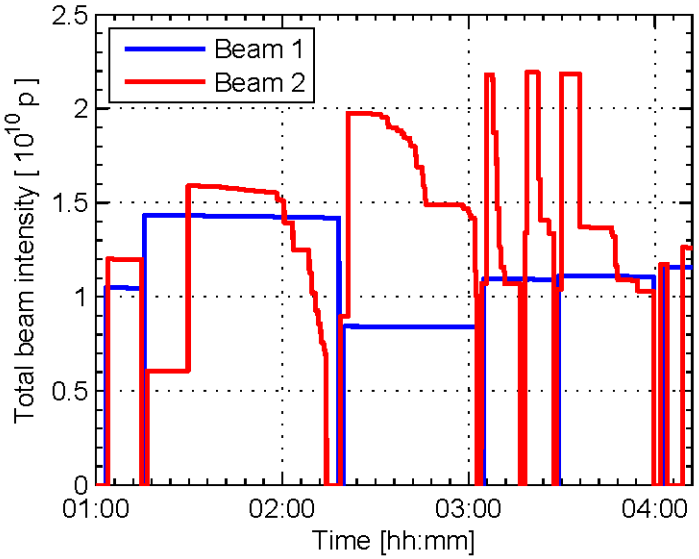


- white noise generated on FPGA running at 40 MS/s
- deployed on a test crate in SR4 with gating
- connected to all dampers of beam 2 (H and V plane)
- noise can be filtered by IIR lowpass filter
- noise triggered for up to 1 second, repetitively also, typically 5x

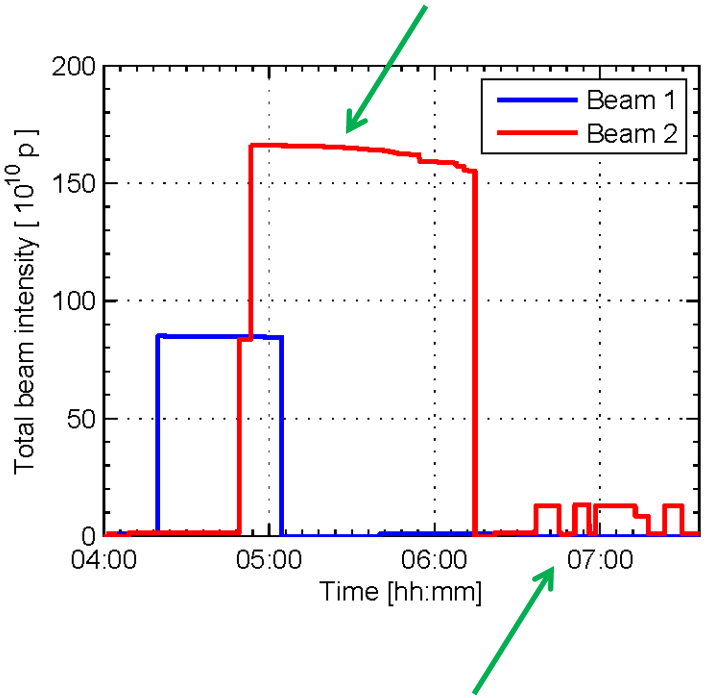
2011 status

First tests in August 2011 (only beam 2 available)

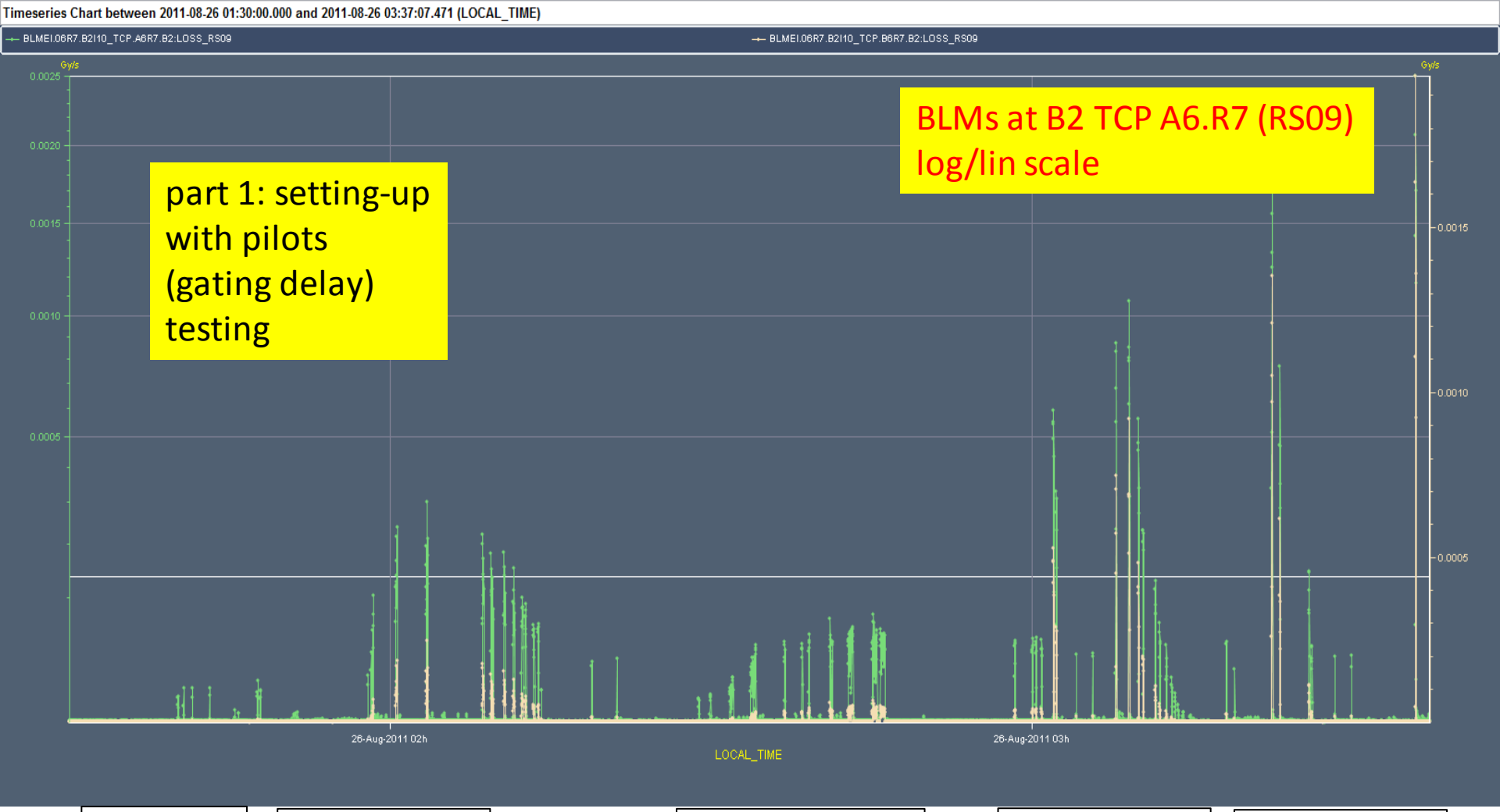
Part 1, 2 pilot bunches



Part 2, 12 nominal bunches



Part 3, loss maps (one nominal bunch)



Adjustment of system

Excitation full bandwidth, Amplitude 0.2, v-plane Beam 2

Excitation reduced bandwidth 500 kHz, Amplitude 0.2, v-plane Beam 2

Excitation full bandwidth, Amplitude 1.0, v-plane Beam 2

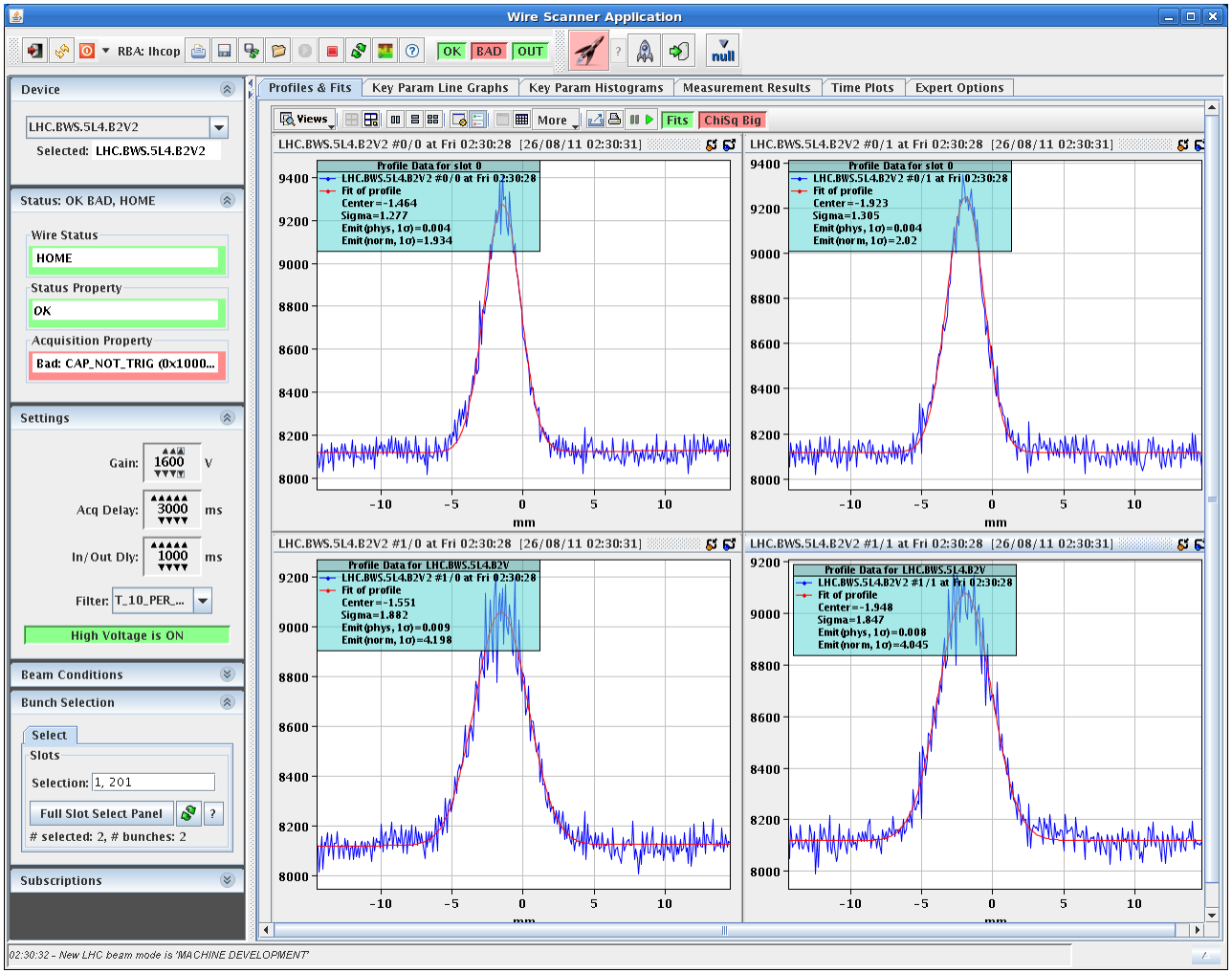
Excitation full bandwidth, Amplitude 1.0, h-plane Beam 2

1:30

Excitation full bandwidth, Amplitude 1.0, h-plane Beam 2

3:36

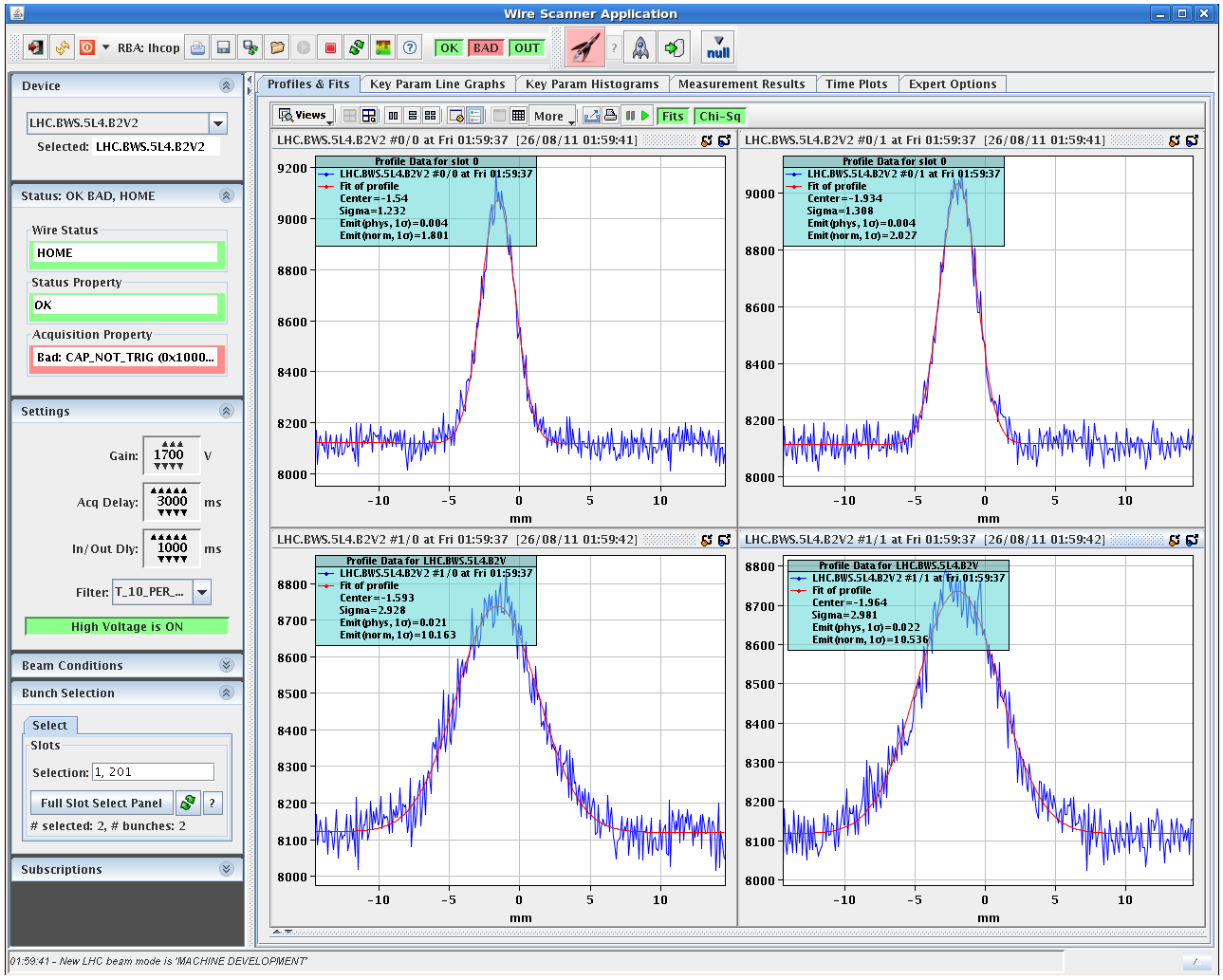
Selective blow-up (2 pilots)



2 μm

4 μm

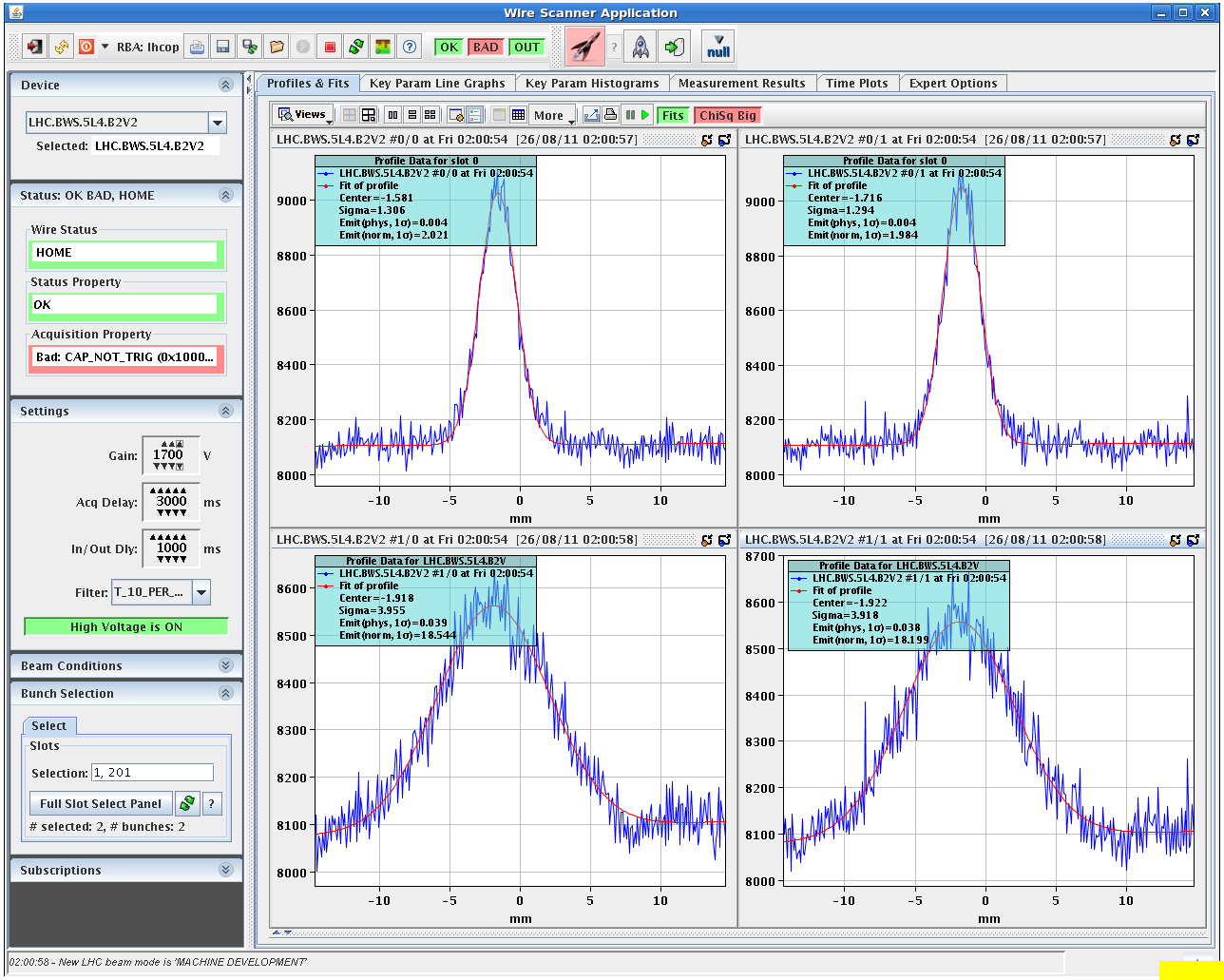
Selective blow-up (2 pilots)



2 μm

10 μm

Selective blow-up 2 pilots)

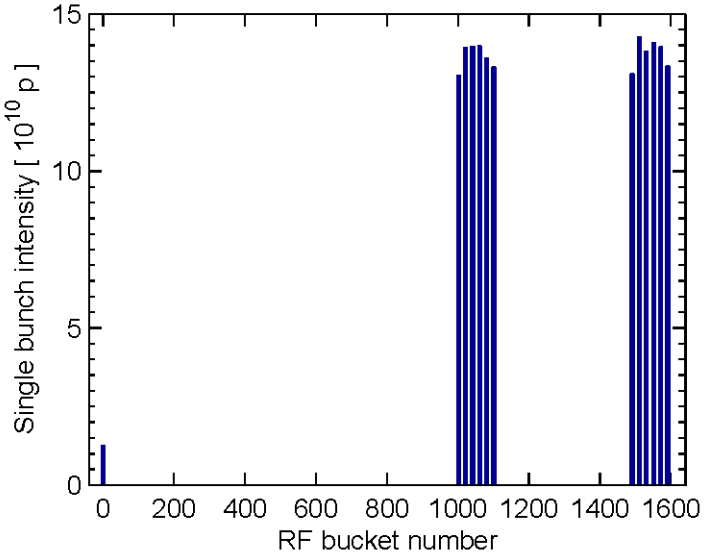


2 μm

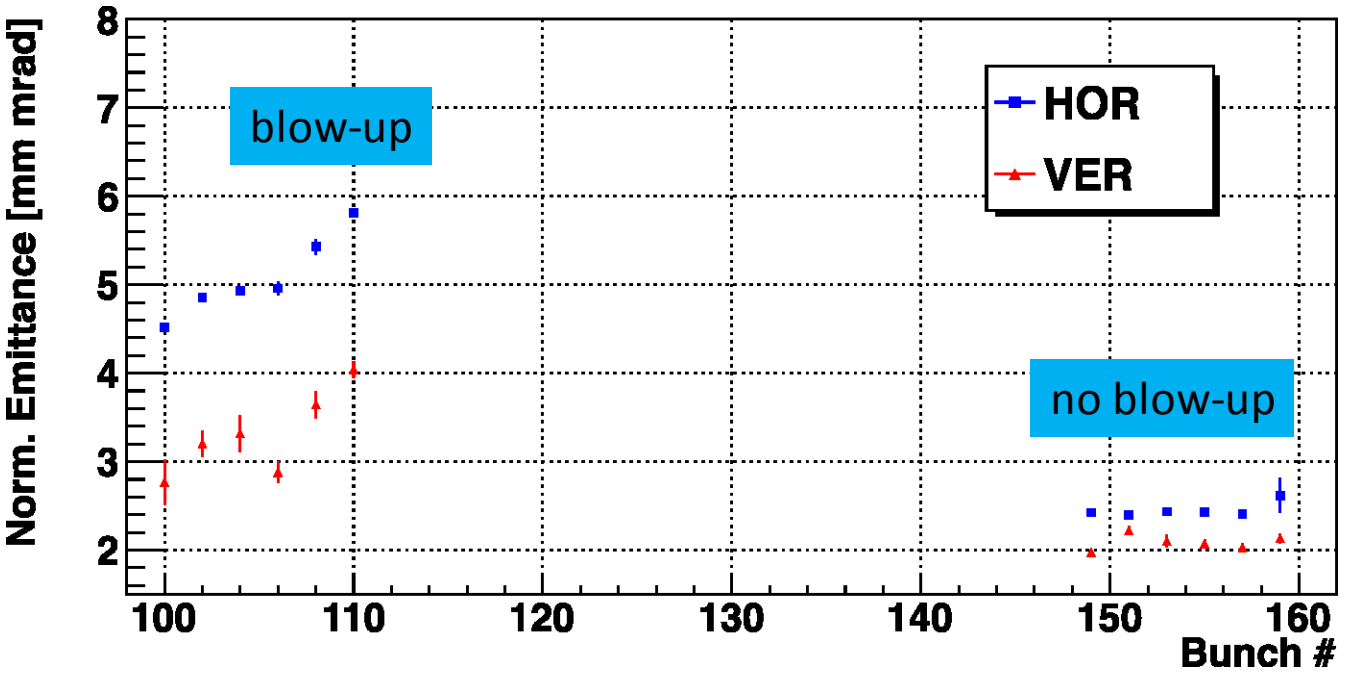
18 μm

stops at 18 μm

batch selective blow-up



2x6 bunches spaced 925 ns (+pilot)

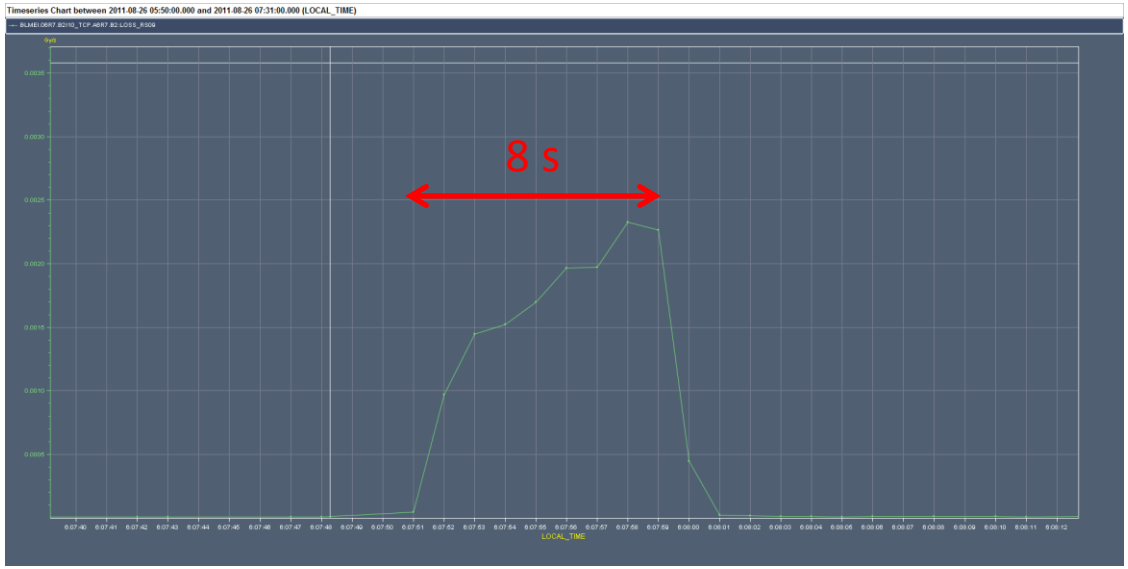


Losses seen on BLMs (example)

Table 1: Relevant times of loss maps performed during the blow-up studies and beam and blow-up parameters.

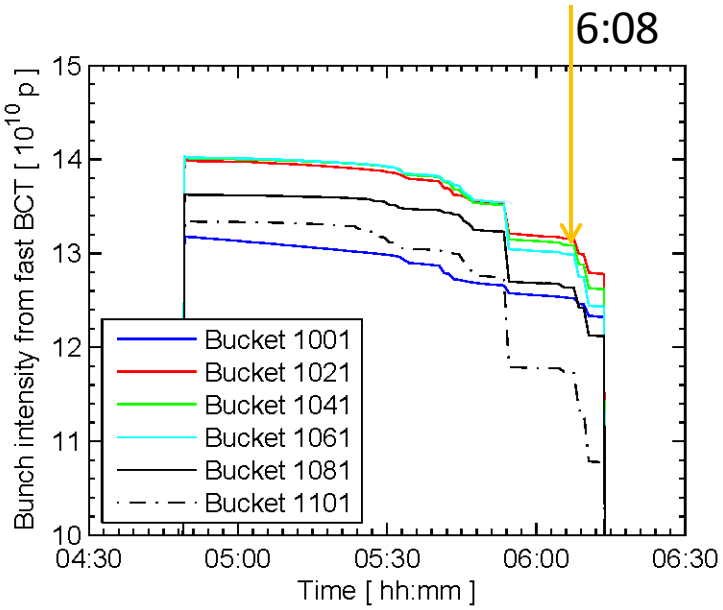
Num.	Time	Plane	Method	Duration	N_b	Amplitude
(1)	05:54	H	Blow-up	5 s	12	Full excitation
(2)	06:08	V	Blow-up	8 s	12	Full excitation
(3)	06:10	V	Blow-up	8 s	12	Full excitation
(4)	06:45	H	Resonance	8 s	1	no excitation
(5)	06:56	H	Blow-up	8 s	1	Full excitation, FB on
(6)	07:12	H	Blow-up	8 s	1	Half excitation, FB on
(7)	07:17	H	Blow-up	8 s	1	Full excitation, FB off
(8)	07:29	H	Blow-up	8 s	1	Half excitation (?), FB off

losses at TCP A6.R7.B2
(M. Sapinski)

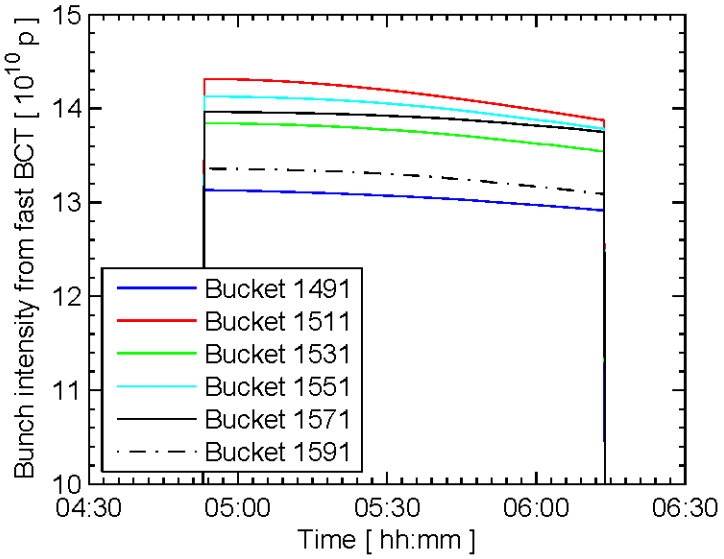


Batch selective blow-up - losses

blow-up / loss

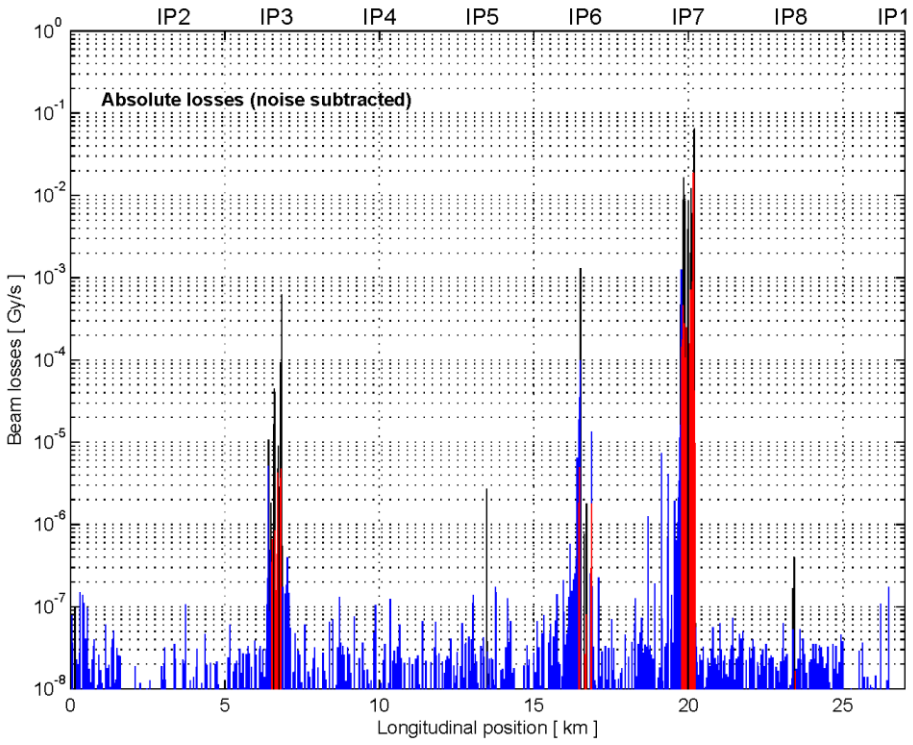


no blow-up

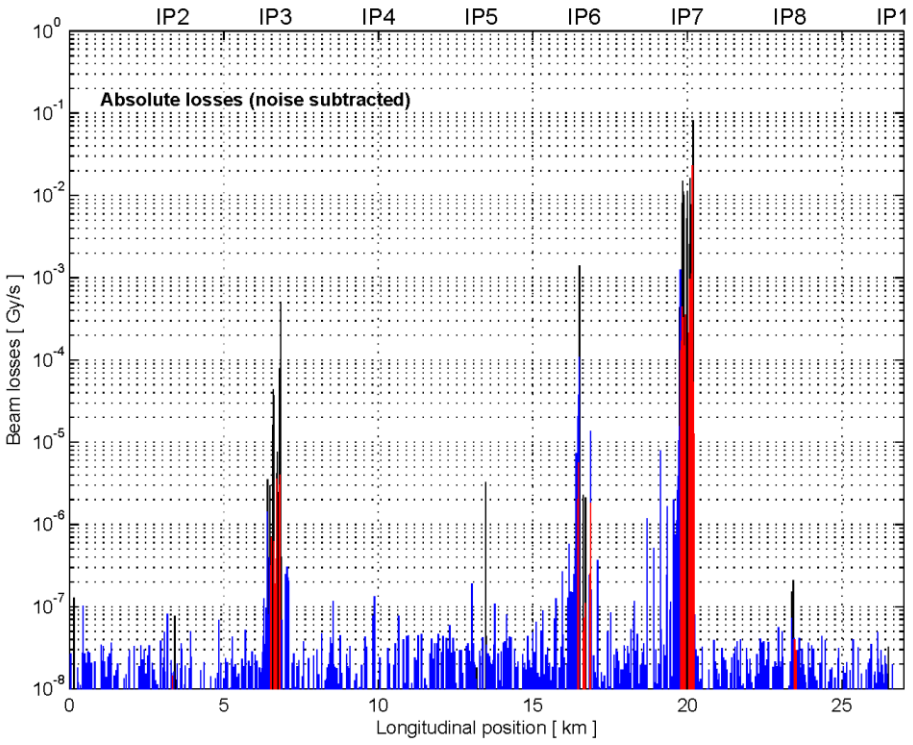


Comparison loss maps

damper loss map



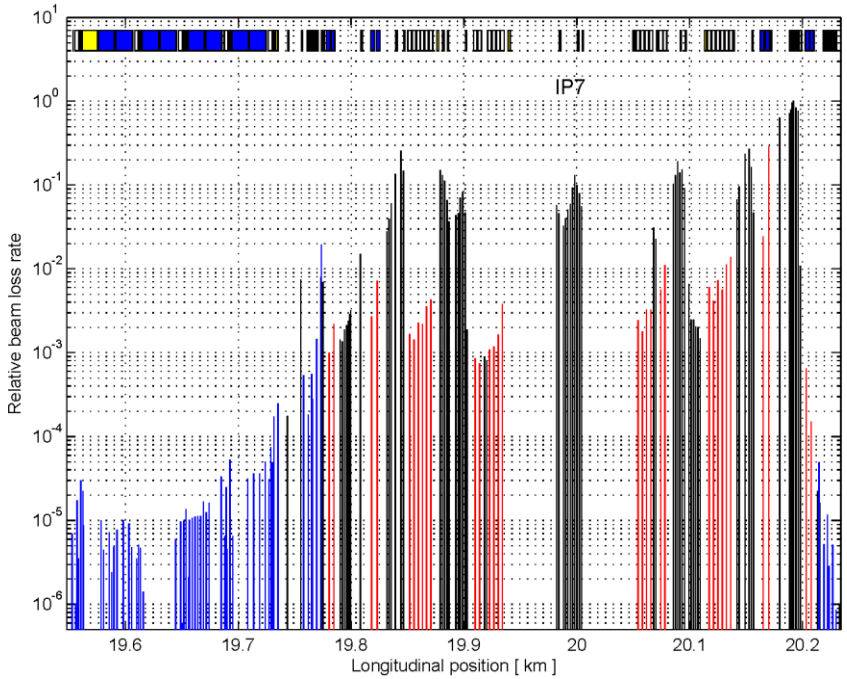
3rd order resonance



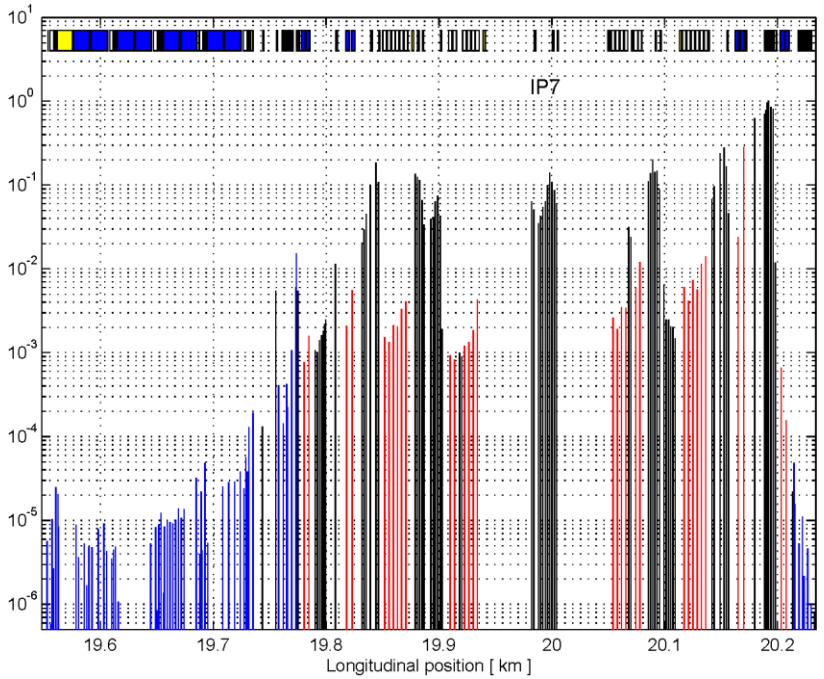
Comparison loss maps (details)

new software interface for ADT blow-up under commissioning (March 2012)

damper loss map



3rd order resonance



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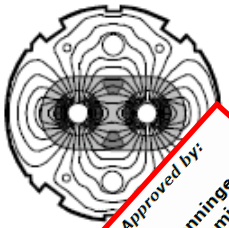

the
Large
Hadron
Collider
project

LHC Project Document No.
LHC-MD-0015 rev 0.4

CERN Div./Group or Supplier/Contractor Document No.
BE-OP, BE-ABP

EDMS Document No.
1167788

Date: 2011-10-31

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LHC MD Test Program – MD Class C & D

QUENCH MARGIN AT 3.5 TEV

(DS QUENCH TEST 2)

Abstract

This note summarises the detailed program proposed for the further qualification of single diffractive scattering to the DS region of IR7 and for the combined cleaning collimator settings in IR3, which will be evaluated during an MD on 3rd of November 2011.
The detailed program along with the necessary modifications of the machine protection systems is presented and responsibilities for the latter are defined.

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3.1 PREPARATION OF THE MD

1. Adjust BLM thresholds and monitor factors for the IR7 tests as for the DS-Quench test in May 2011. The details are described in [3] and [4]. (**Responsible: BLM team**)
2. Adjust BLM thresholds and monitor factors for the IR3 tests as described in LHC-BLM-ECR-0028 (see https://edms.cern.ch/document/1168274/1). This is based on the limiting BLMs found during the IR3 combined cleaning MD in B2 and off-momentum loss maps with both beams. (**Responsible: Coll + BLM team**)
3. Adjust BLM thresholds for wire scanner quench test. (**Responsible: BLM team**)
4. Move BLMs quoted in LHC-BLM-ECR-0020 (see https://edms.cern.ch/comment/1143931/1) into the three new BLM families. **(Responsible: BLM team)**
5. Drive the new thresholds to hardware. **(Responsible: BLM team)**
6. Perform MCS check. **(Responsible: BLM team)**
7. Perform BLM sanity check. **(Responsible: BLM team / OP)**
8. Compare the thresholds before and after the changes for all running sums, plot threshold ratios (new/old) and re-check the changes (for 3.5 TeV). **(Responsible: COLL + BLM team)**

achieve loss rates of 9×10^{11} protons/s

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Number of MD's	1
Time required per MD [h]	8
Beams required [1, 2, 1&2]	1&2
Beam energy [GeV]	3.5TeV
Optics (injection, squeezed, special)	Nominal optics, un-squeezed, non-colliding
Bunch intensity [#p, #ions]	Nominal bunch (1.2E11)
Number of bunches	1) 1x pilot + 2x trains of 12 bunches spaced by 925ns @450GeV. 2) 1x pilot + 2x trains of 12 bunches spaced by 925ns @450GeV. 3) 1 train of 12 bunches and 2x trains of ~108 bunches spaced by 925ns @450GeV. 4) 3 trains of 12 bunches and 2x trains of ~108 bunches spaced by 925ns @3.5TeV. 5) Trains of 12, 32, 64 and ~108 bunches spaced by 925ns @3.5TeV.
Transv. emittance [m rad]	Not relevant
Bunch length [ns @ 4s]	Not relevant
Optics change [yes/no]	No
Orbit change [yes/no]	No
Collimation change [yes/no]	Yes: IR3 collimators to 4/6/8 nominal sigma (TCP3/ TCSG3/TCLA3)
RF system change [yes/no]	No
Feedback changes [yes/no]	No
What else will be changed?	No
Are parallel studies possible?	No
Other info/requests	Changes of BLM thresholds, ADT noise facility to create controlled losses

Table 1: Machine parameters during the MD

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2. GOALS OF THE MD

Following the experience of the first Collimation losses – DS Quench test MD and the MD with the ADT, we propose a staged approach:

Note: In standard operation the ADT is used in damping mode to stabilize the beam. In this MD we will use the ADT in addition to this in excitation mode. Therefore, *damper OFF* means in the following that the damping mode of the ADT is turned off. Besides ON or OFF we will also change the gain of the damping mode.

Fill 1 at 450 GeV: **[~30min]**

- All tests will be performed in beam 1 and beam 2 sequentially.
- Inject two trains, each with 12 bunches, spaced by 925 ns.
- Check the gate phasing of the ADT, possibly adjust it.
- Test the achievable loss rates with damper ON and OFF.

Fill 2 at 450 GeV: **[~15min]**

- All tests will be performed in beam 1 and beam 2 sequentially.
- Inject two trains, each with 12 bunches, spaced by 925 ns.
- Check the achievable loss rates for different damper gains.
- Test the achievable loss rates with damper ON and OFF. These results will be used to confirm the intensity required to achieve loss rates of 9e11p/s @3.5TeV (i.e. 500kW at primary collimators).
- Calculate the needed beam intensity to create a loss-rate of 9e11p/s with the tested ADT parameters (~108 bunches).

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Fill 3 at 450 GeV: **[~15min]**

- All tests will be performed with beam 1 and beam 2 sequentially.
- Inject one train of 12 bunches and two trains of ~108 bunches (or the number of bunches derived from the results in Fill 2) spaced by 925ns.
- Check the achievable loss rates for the damper gains that have been established in the previous fills.

In case that fill 1 to fill 3 are successful:

Fill 4 with ramp to 3.5 TeV: **[~3.0h]**

- All tests will be performed **first in beam 1** and the beam 2 sequentially.
- Inject three trains of 12 bunches and two trains of ~108 bunches spaced by 925ns.
- Ramp the beam to 3.5 TeV
- Excite the first train of 12 bunches with the ADT parameters achieved and tested at 450GeV (peak to peak voltage, damper gain, ...). Measure the achieved loss rate and derive/check the scaling law ($\sqrt{\gamma}$?) to achieve the same loss rate as at 450GeV. From MD3 and the test on 07.05.2011 it was extrapolated that @3.5TeV an ADT voltage of 560mVpp is needed at the input of the preamplifier in SR4 (referring to the same point in the damper feedback loop as during the tests on 07.07.2011) to lose all particles in the gated window within ~10s.
- Excite the second train of 12 bunches with the ADT parameters derived from the previous test. Check scaling law and if needed optimize the ADT parameters to loose the gated train in ~10s.
- If needed repeat the test with the optimized ADT parameters with the third train of 12 bunches.
- Excite the 108 bunches train with the ADT parameters achieved during the optimization to loose the full 108 bunches within 10s. This should give a peak loss rate of ~9e11p/s at the primary collimators of IR7.

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Fill 5 with ramp to 3.5 TeV: **[~3.0h]**

- Test with IR3 combined cleaning settings will be performed in beam 1. Beam 2 will be filled to perform the wire scanner quench test.
- B1: Inject trains of 12 bunches, 32 bunches, 64 bunches and 108 bunches, all spaced by 925 ns. This filling pattern is applied to create losses with increasing loss rate from ~1e11p/s up to ~9e11p/s.
- B2: Inject trains 12-32-64-108-108 bunches, all spaced by 925 ns. This fill in B2 will be used to perform a wire scanner quench test.
- Move the horizontal collimators in IR3 to *tight settings*: TCP3: 4, TCSG3: 6 and TCLA: 8 nominal sigma. The collimators in IR7 will stay at their nominal settings.
- B1:
  - Excite (horizontal only) the train with 12 bunches using the ADT parameters achieved in Fill 4. Check the achieved loss pattern.
  - If loss pattern is ok, no unexpected losses in the cold magnets appeared, excite the train with 32 bunches.
  - If loss pattern is ok and no unexpected losses in the cold magnets appeared, excite the train with 64 bunches.
  - If loss pattern is ok and no unexpected losses in the cold magnets appeared, excite the train with 108 bunches.
- B2:
  - Perform wire scanner quench test, when IR3 combined cleaning tests were finished.

Summary

- 2011 tests of ADT blow-up successfull
- new software being commissioned
- first application → loss maps
- procedure for Quench Margin test established
- Quench Margin test will likely take place only
  at the end of 2012 run → ample time to gain experience with the system during loss maps (calibration of losses)