GENERATION OF CONTROLLED LOSSES IN MILLISECOND TIMESCALE WITH TRANSVERSE DAMPER IN LHC

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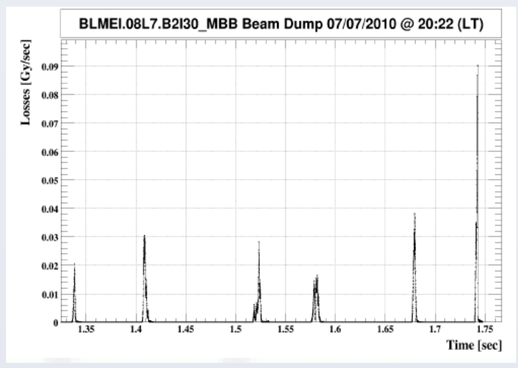
Abstract

A controlled way of beam losses generation is required in order to investigate the quench limits of the superconducting magnets in the LHC. This is especially difficult to achieve for losses with millisecond duration. A series of experiments using the transverse damper system has proven that such a fast loss can be obtained even in the case of rigid 4 TeV beams. This paper describes the optimization of beam parameters and transverse damper waveform required to mimic fast loss scenarios and reports on the tracking simulations undertaken to fully understand the temporal and spatial structure of these losses. The application of this method to the final quench tests is also presented.

UFOs

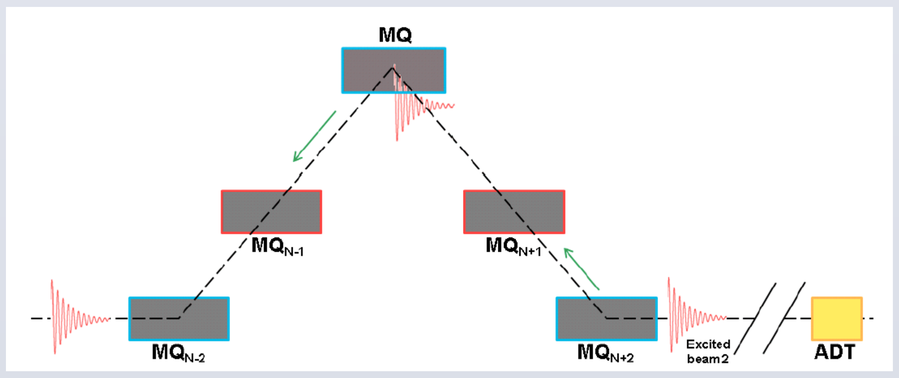
On July 7, 2010 LHC beams were dumped due to unexpected fast beam loss. After many studies [UFO] they are suspected to be due to macroparticles falling into the beam (*Unidentified Flying Objects* – UFO).



During Run 1 total number of 58 fills have been dumped due to UFOs by Beam Loss Monitors (BLMs). But no magnet was quenched. Therefore the mitigation applied was empirical increase of BLM thresholds for millisecond losses as operational evidence suggested that quench limit is higher than initially expected.

Experiments performed to investigate quench limit in millisecond timescale:

- using loss generated by a wire scanner [WireScannerTest] (in 2010)
- using transverse damper [ADT] (in 2013)



Preparatory tests

Seven planning meetings, four tests with beams, numerous discussions with Machine Protection Panel.

1. Testing excitation method

Test performed on 26 March 2012 with pilot bunch ($5 \cdot 10^9$ protons) at injection energy.

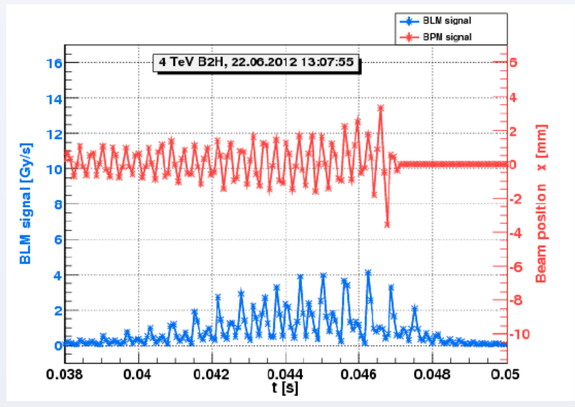
There are three excitation methods possible with ADT:

1. coherent excitation where beam is excited with frequencies swept around the beam tune; it is used to clean the abort gap,
2. white noise excitation, also used to blow up the beam emittance in the loss map procedure which is used to verify the hierarchy of collimator setup,
3. feedback sign flip, which locks on the beam tune with positive feedback.

The feedback sign flip gave the best results as seen by BLMs and BPMs.

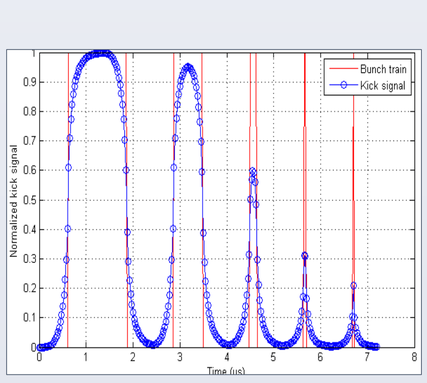
2. Testing procedure at 4 TeV

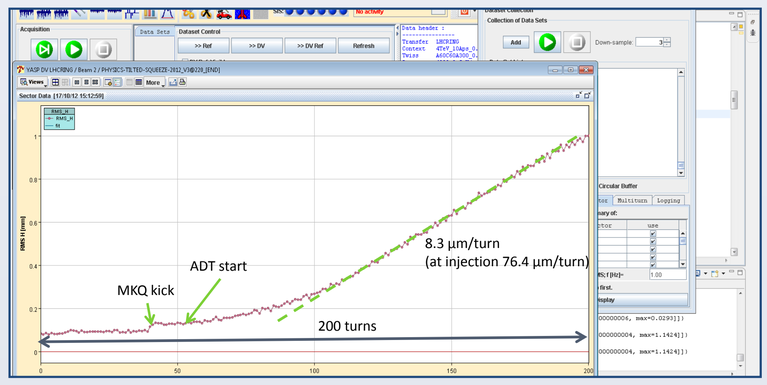
On 22 June 2012 the procedure was tested in special Machine Development time at beam energy of 4 TeV. Asymmetric setting of collimators was used. Bunch-by-bunch excitation was tested as planned for the final experiment [4TeVtest].



3. Adding tune kicker and modifying ADT gating

On 13 October 2012 the procedure was tested again, this time adding tune kicker (MKQ) kick to start the beam excitation in a more controlled way.





The gating window of ADT was increased to more than 1 μs in order to profit from the full strength. That is still small enough to be able to excite 10 bunches separately.

4. Tuning ADT and instrumentation for ultra-low intensity

Quench expected at a loss of ~10^8 protons. LHC pilot bunch: $5 \cdot 10^9$ protons. Need to tune ADT, wire scanners, BPMs, BCTs to this low intensity. Scraping procedure:

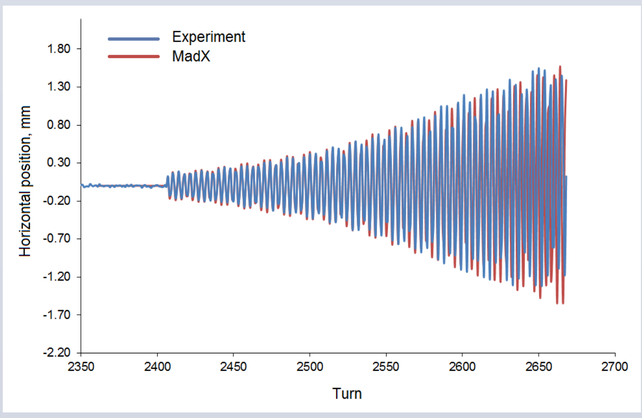
- blow beam vertically (80 μm) and scrape on collimators down to ~10^8 p.
- keep horizontal emittance small (0.5 μm)

Quench test

On 15 February 2013 magnet was quenched with about $4 \cdot 10^9$ protons. Loss duration was about 5 ms, spiky structure [Quenches]. Analysis ongoing.

Simulations

Dedicated tracking studies with MadX. Goal: understand spatial and temporal loss structure. Comparison of measured and simulated BPM readings looks promising. This input will be used for particle shower simulations.



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