1st BLMTWG Meeting, 27.05.2014, B. Auchmann, O. Picha
with help from M. Sapinski, E.B. Holzer, A. Priebe.

The dynamic orbit bump quench test and its impact on BLM thresholds.

Overview

- Recall the dynamic orbit-bump QT.
- History of the assumed signal at quench.
- Corrections due to dynamic orbit-bump QT.
- Re-analysis in QTAWG.
- Conclusions and next steps.

Dynamic Orbit Bump QT

- 17.10.2010, 20h23.
- 3-corrector bump.

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Bump used for the quench test, trim integral at 21 mm when quenching.

MCBV.12R2.B2    RCBV12.R2B2      5.659
MCBV.14R2.B2    RCBV14.R2B2      -0.557
MCBV.16R2.B2    RCBV16.R2B2      5.728

we did not revert the trim as convrters are down and BP will anyway be regenerated at the next ramp.
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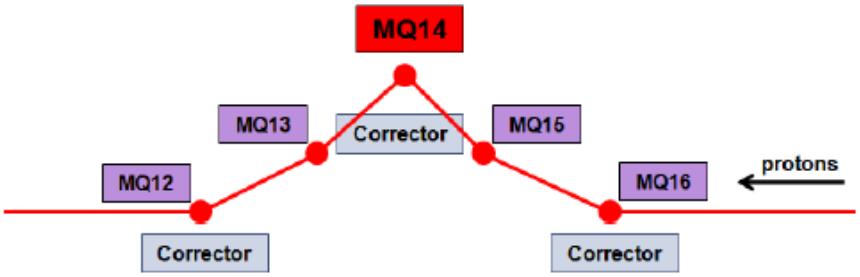
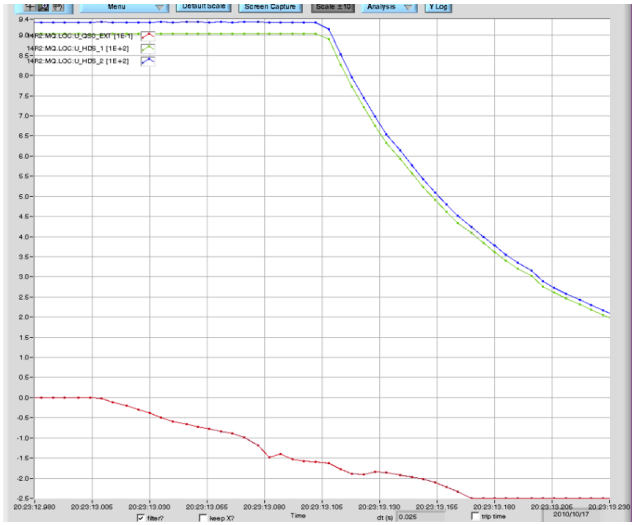
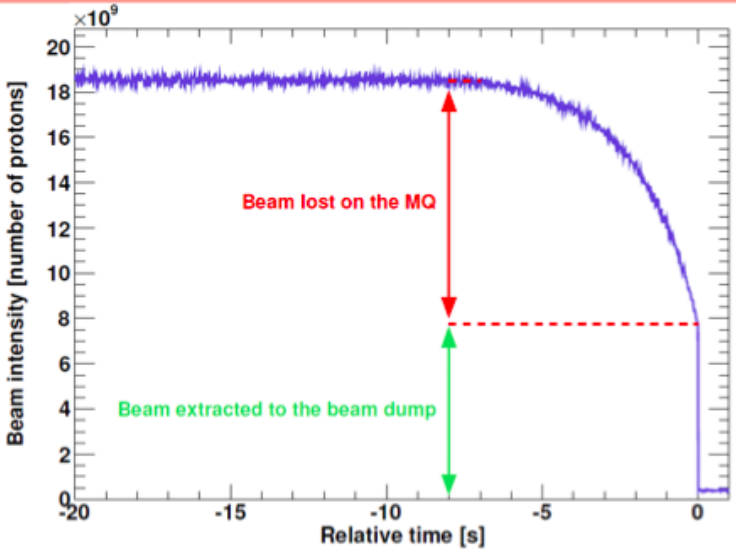
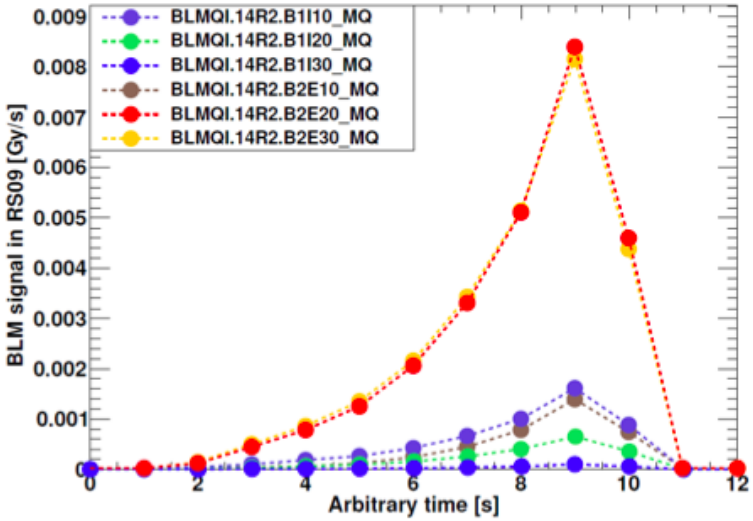


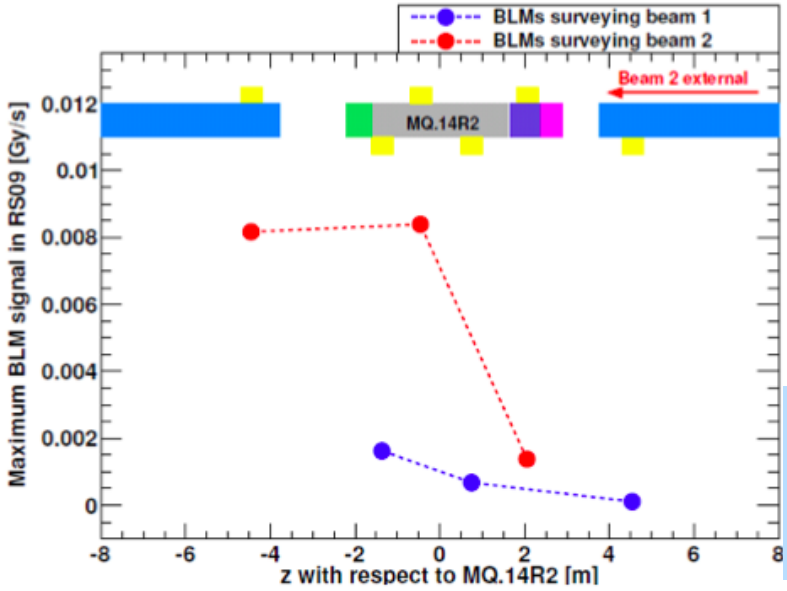
courtesy A. Priebe



EXPERIMENT







- Three pilot bunches with intensities of (5-6) $\cdot 10^9$ + (total 1.85 $\cdot 10^{10}$ p+)
- Loss rate increasing in time
- Loss duration: around 6 s

RS09 threshold at the time:
52 mGy/s for horizontal losses.
Factor ~1/3 was applied for vert. losses.

Assumed BLM signal at quench

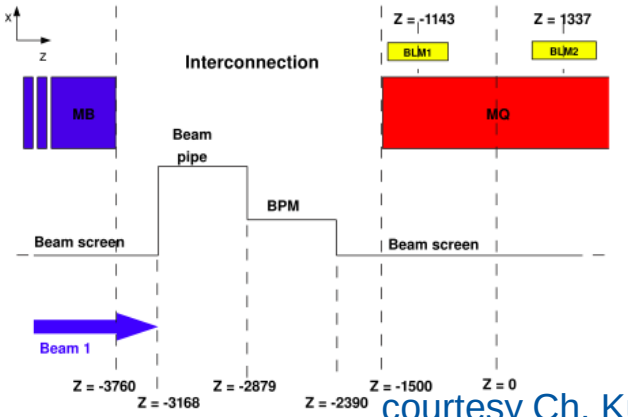
- The assumed signal at quench is composed of three input factors:

$$\mathrm{BLMSignal@Quench}(E,t) = \frac{\mathrm{BLMResponse}(E,t) * \mathrm{QuenchLevel}(E,t)}{\mathrm{EnergyDeposit}(E,t)}$$

- Its units are $\mathrm{mGy} = \frac{\mathrm{mGy/p} * \mathrm{mJ/cm^3}}{\mathrm{mJ/(cm^3 p)}}$

Assumed BLM signal at quench 2008-1011

- At LHC startup, MQ arc BLM thresholds were based on:
  - Ch. Kurfürst diploma thesis on BLM thresholds in MQs, i.e., losses in the interconnections.
  - Report 44 quench levels.



courtesy Ch. Kurfürst

- In 2009 the assumed energy-deposition / proton in BLMs 2 and 3 were replaced by a Geant4 model for the first beam-induced quenches in MBs (Note 422, horizontal distributed losses)*.

E_{beam} [TeV]	E_D^{cable} [mJ/cm^3] per proton	quench limit P_{QL}[mW/cm^3]	proton rate to quench [s^{-1}]	proton rate in max [s^{-1}m^{-1}]
horizontal, pointlike loss				
0.45	$2.43 \cdot 10^{-8}$	320	$1.32 \cdot 10^{10}$	-
7	$8.05 \cdot 10^{-7}$	12	$1.49 \cdot 10^{7}$	-
vertical, pointlike loss				
0.45	$1.08 \cdot 10^{-8}$	320	$2.96 \cdot 10^{10}$	-
7	$4.21 \cdot 10^{-7}$	12	$2.85 \cdot 10^{7}$	-
horizontal, distributed loss				
0.45	$1.22 \cdot 10^{-9}$	320	$2.63 \cdot 10^{11}$	$2.58 \cdot 10^{10}$
7	$1.83 \cdot 10^{-8}$	12	$6.56 \cdot 10^{8}$	$6.45 \cdot 10^{7}$
vertical, distributed loss				
0.45	$8.50 \cdot 10^{-10}$	320	$3.77 \cdot 10^{11}$	$3.71 \cdot 10^{10}$
7	$6.22 \cdot 10^{-9}$	12	$1.92 \cdot 10^{9}$	$1.89 \cdot 10^{8}$

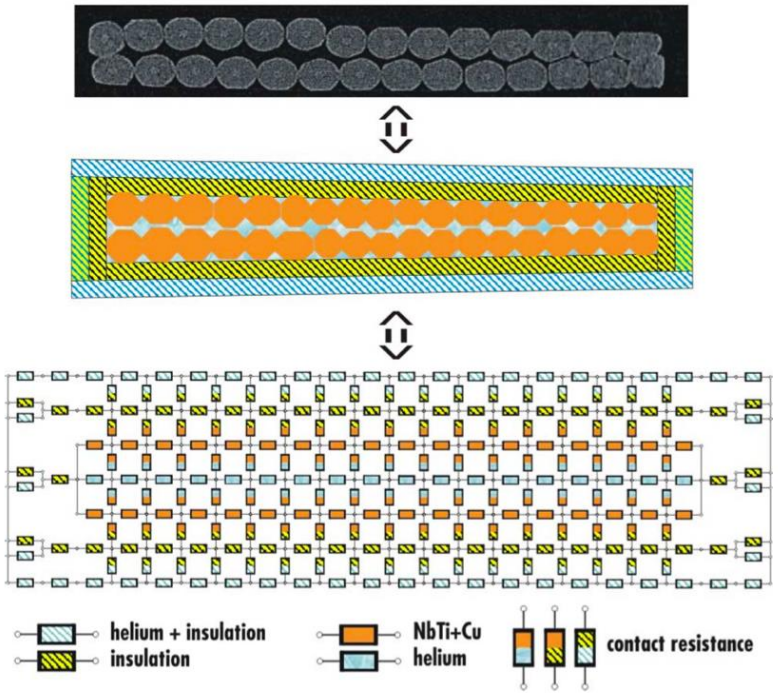
Table 3: *Energy density depositions in thermal equloibrium volumes E_D^{cable} (per proton), quench margin in the cable and the resulting maximal proton loss rate for various loss configurations and beam energies. In case of distributed loss a loss rate density in the loss maximum is also given.*

Note 422

- *…vague agreement. other sources?

Assumed BLM signal at quench 2008-1011

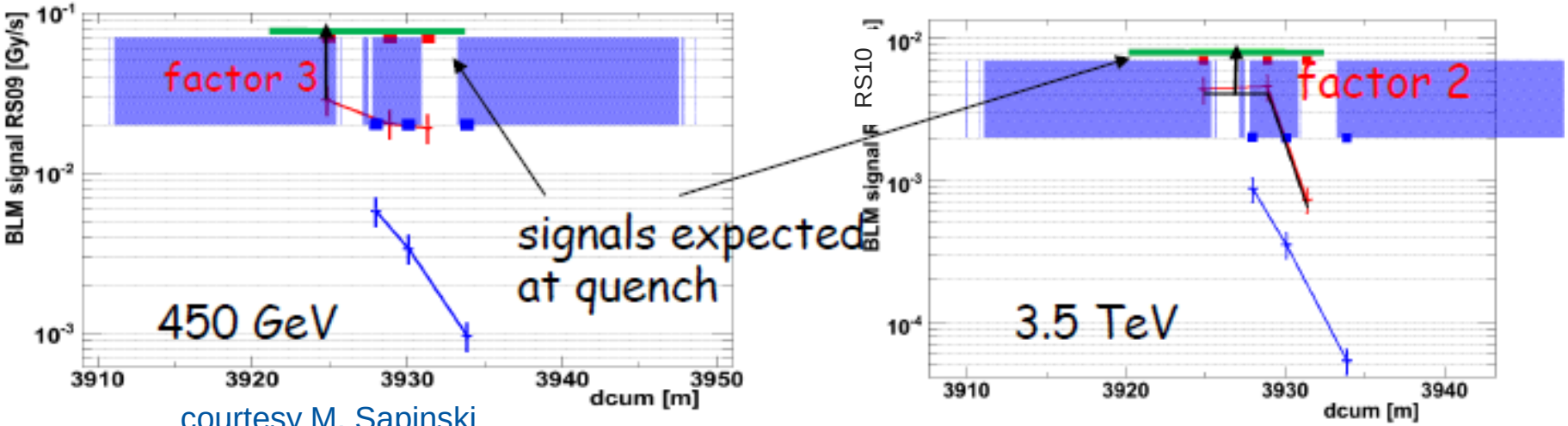
- In 2010 the steady-state quench level was still computed according to Report 44, but with input from the D. Bocian 2-D model.



courtesy D. Bocian

Assumed BLM signal at quench 2008-1011

- From Note 422 it was inferred that BLM signals for vertical losses may be >3x lower than for horizontal losses.
- The below plots are from a preliminary analysis of the events in Oct. 2010.
- The green lines represent the assumed BLM signal at quench in RS10 (5.24 s) divided by 3.5 to convert to a vertical loss scenario.



courtesy M. Sapinski

Assumed BLM signal at quench 2008-1011

- Ad hoc corrections of thresholds for startup 2011

	RS01	RS02	RS03	RS04	RS05	RS06	RS07	RS08	RS09	RS10	RS11	RS12
Ad hoc	3	3	5	5	5	1	0.33	0.33	0.33	0.33	0.33	0.33
MF	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

High luminosity runs

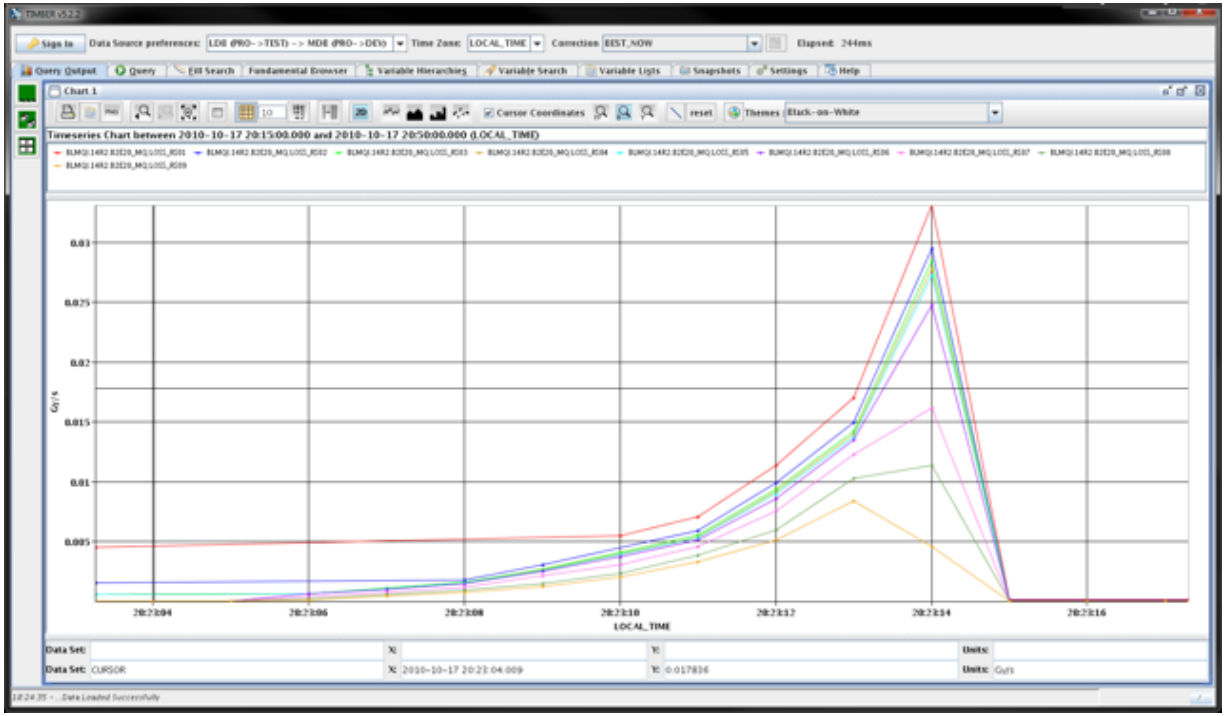
UFOs

Preliminary dynamic orbit bump data

- Question: Can we explain the factor 0.33 after a MAD-X/FLUKA/QP3 re-analysis?

QTAWG results

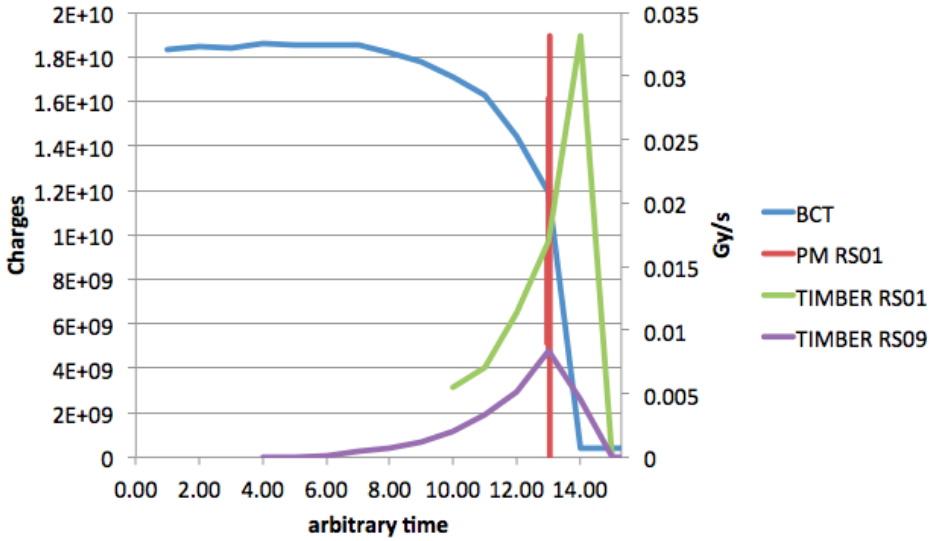
- Re-understand the signals

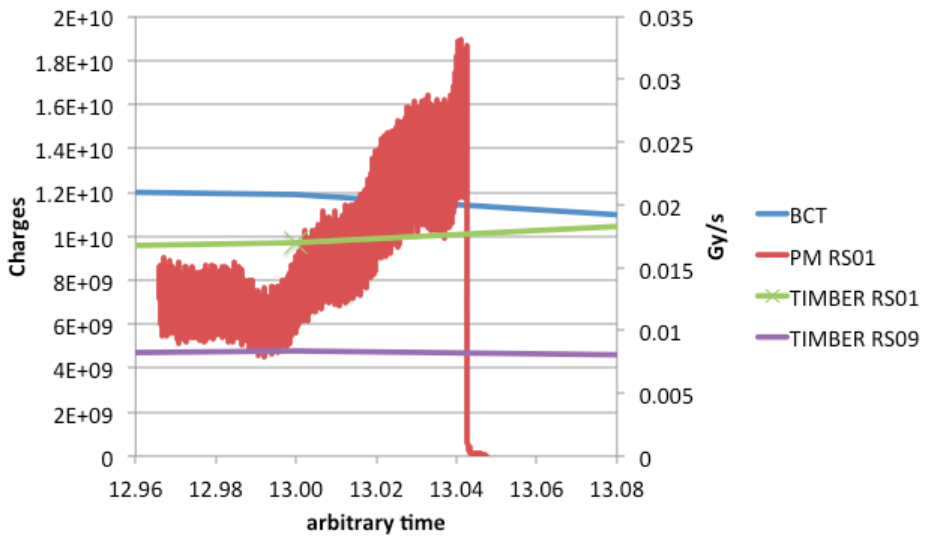


RS01-09: large variation for steady-state test!

QTAWG results

- Re-understand the signals





- Loss spike in the last 40 ms explains the variation, between running sums.
- Combined slow- and intermediate-duration loss scenario!

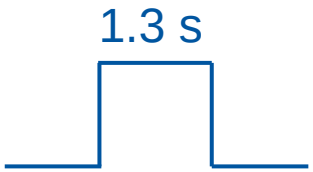
QTAWG results

- Re-understand the signals

- The cell 14 thresholds were reduced by a factor ~3.5; likely to adjust the assumed beam-loss scenario to vertical losses, based on Note 422 results.

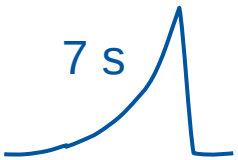
QTAWG results

- Quench levels in RS09:
  - Report 44 / Bocian: 200 mJ/cm^3
  - QP3 + 10-stack data: 240 mJ/cm^3



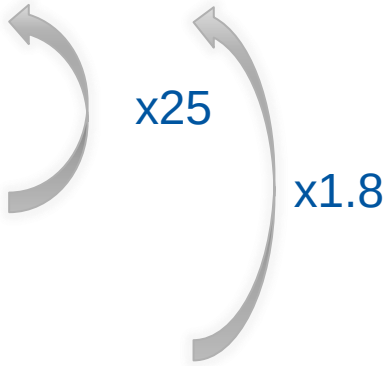
P. P. Granieri, Heat Transfer between the Superconducting Cables of the LHC Accelerator Magnets and the Superfluid Helium Bath. PhD thesis, EPFL, Lausanne, 2012.

- Quench levels for quench test loss profile
  - QP3 + 10-stack data: 373mJ/cm^3



QTAWG results

- Energy deposition in coils:
  - Kurfürst thesis: 1.1E-07 mJ/(cm^3 p)
  - Note 422: 4.26E-09 mJ/(cm^3 p)
  - FLUKA model: 6.1E-08 mJ/(cm^3 p)



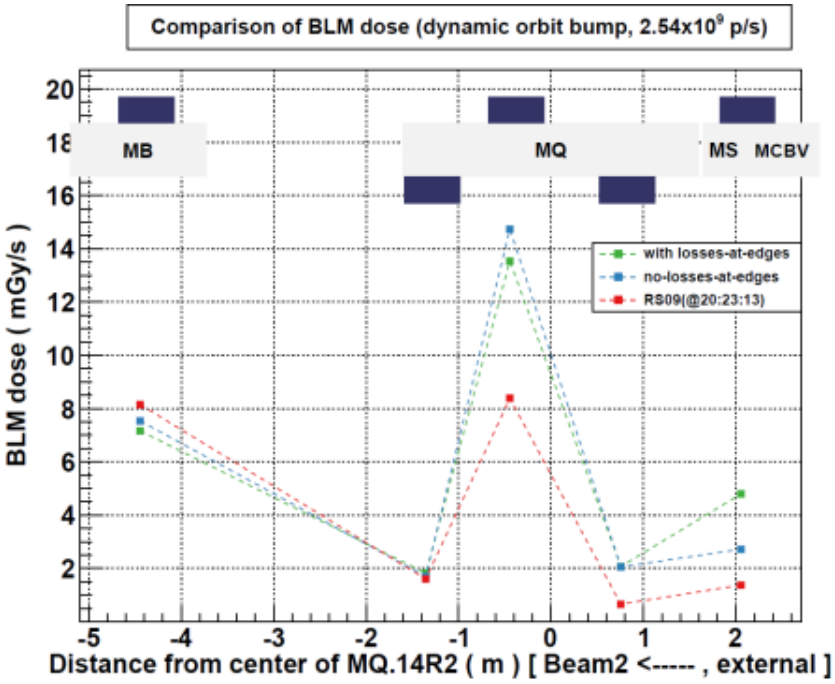
- Consistency check
  - Np = 0.88E10
  - QuenchLevel = 373 mJ/cm^3

Scenario	Edep x Np
Kurfürst thesis	968 mJ/cm^3
Note 422	38 mJ/cm^3
FLUKA	536 mJ/cm^3

QTAWG results

- BLM signals:
  - Kurfürst thesis: 1.44E-06 mGy/p
  - FLUKA model: 5.3E-06 mGy/p (validated within 30%)

x1/4



- MAD-X / FLUKA simulation normalized to losses in the last second.
- FLUKA data in FLUKA/BLM comparison is to be reduced by ~20% to account for losses on the collimators.
- Resulting BLM signal agreement within 30%.

courtesy N. Shetty

Thresholds corrections

- RS09 (1.3 s) models vs. measurement in BLM position 2.

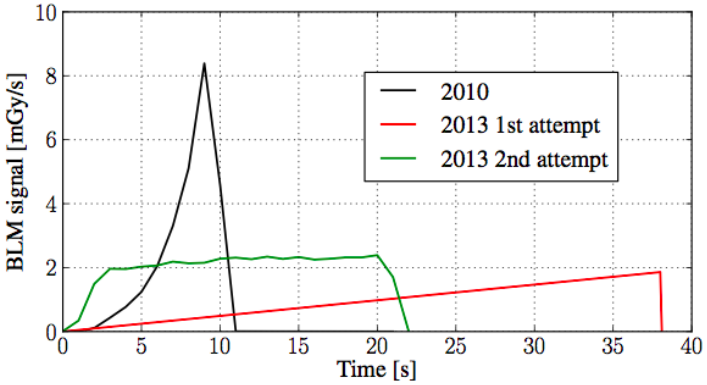
Model	Loss	Quench Level [mJ/cm^3]	Energy deposition [mJ/(cm^3 p)]	BLM signal [mGy/p]	BLM signal @ quench [mGy]
Bocian/Kurfürst	hor.	200	1.07E-07	1.44E-09	**3**
Bocian/Kurfürst/422	hor.	200	4.26E-09	1.44E-09	**67**
QP3/FLUKA	ver.	240	6.1E-08	5.3E-09	**21**
QP3/FLUKA*	hor.	240/96	1.49E-07	7.96E-09	**12/5**
Measured	ver.				**11**
Measured*	hor.				**3**

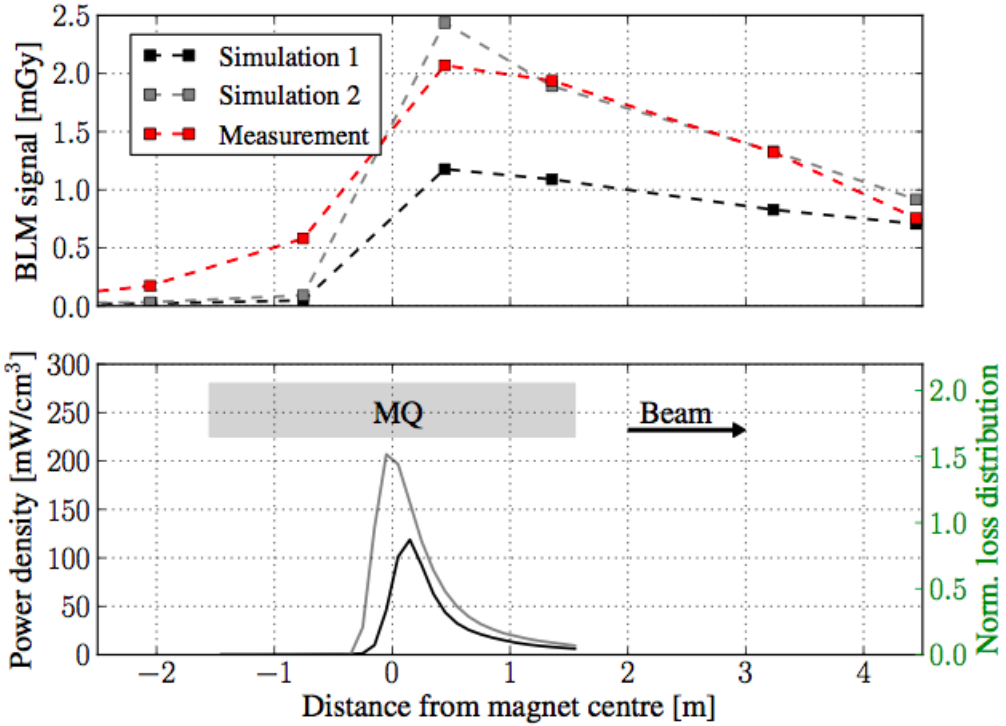
* …2013 steady-state orbit-bump quench test, threshold in RS11 re-scaled to RS09.

Conclusions and Next Steps

- Is a rectangular pulse in time always the best scenario for thresholds?
- Use of Note 422 energy deposition on MQ BLMs seems doubtful.
- Factor 3 was applied throughout (even where the Kurfürst energy deposition is used). This needs to be re-assessed.
- For future thresholds, we need to study in detail BLM positions 1 and 3.

2013 QT analysis





Master Threshold and Monitoring Factors

The master threshold is computed per BLM family:

$$\mathrm{MasterThreshold}(E,t) = 3 * \mathrm{BLMSignal@Quench}(E,t)$$

The applied threshold is the comination of

$$\mathrm{Threshold}(E,t) = \mathrm{MonitorFactor} * \mathrm{MasterThreshold}(E,t)$$

where $\mathrm{MonitorFactor} \in [0.1, 1]$
can be set by the operators.