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5th BLMTWG Meeting, January 27, 2015

BLM Thresholds in IPQs and IPDs

B. Auchmann, O. Picha

Overview

- Threshold computation
- Assumed loss scenarios in the LSS
- Proposal of LSS cold magnet thresholds
- Summary

BLM Threshold Formula

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

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

$$\text{Gy} = \frac{\text{Gy/p} * \text{mJ/cm}^3}{\text{mJ/(cm}^3\text{p)}}$$

The MasterThreshold is a multiple of the BLMSignal@Quench.

$$\text{MasterThreshold}(E,t) \cong N * \text{BLMSignal@Quench}(E,t) * \text{AdHoc}(E,t)$$

The AppliedThreshold is set with the MonitorFactor (0…1].

$$\text{AppliedThreshold}(E,t) = \text{MonitorFactor} * \text{MasterThreshold}(E,t)$$

The factor N shall ensure safety from damage while providing flexibility and room for corrections via the MonitorFactor.

- 2009 Startup for cold magnets: $N = 3$, MonitorFactor = 0.1.

SS Loss Scenarios

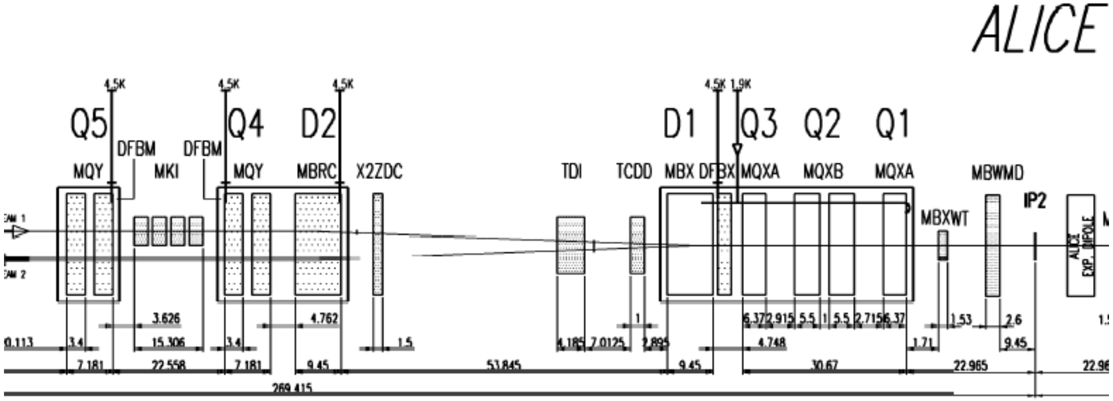
UFOs and orbit bumps.

Uncertainties on BLM locations.

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

MQY UFO

UFOs are simulated in different locations upstream of the MQY 4L2 B1 side. Thresholds are computed for the **10-m-location**, which is a likely scenario for MKI UFOs.



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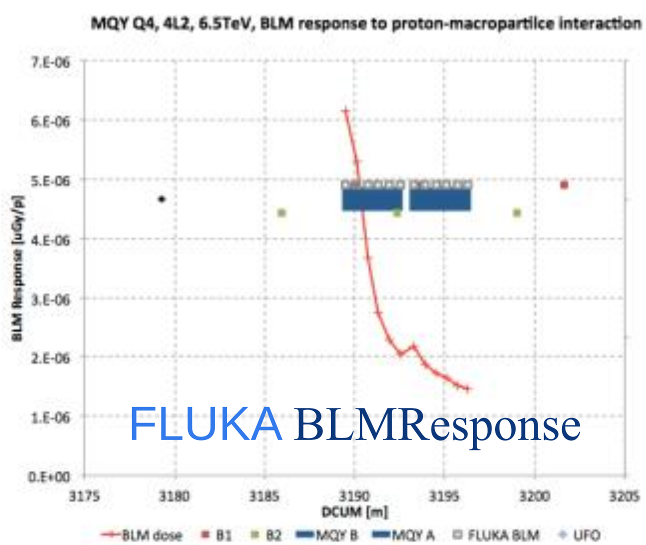
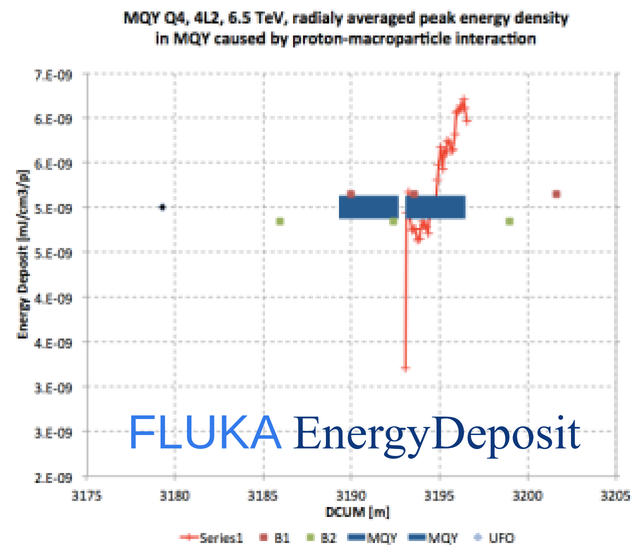
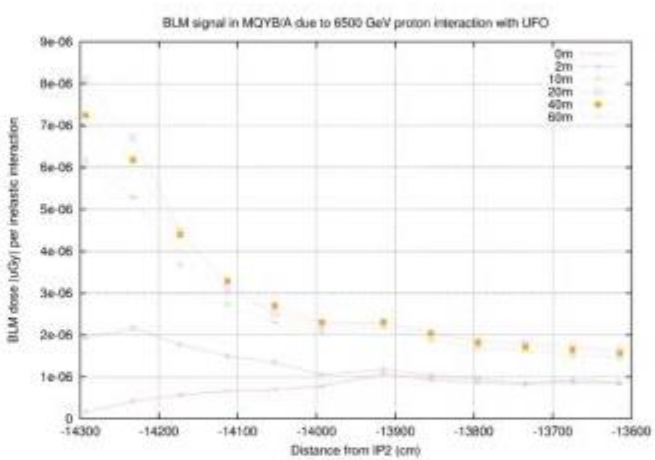
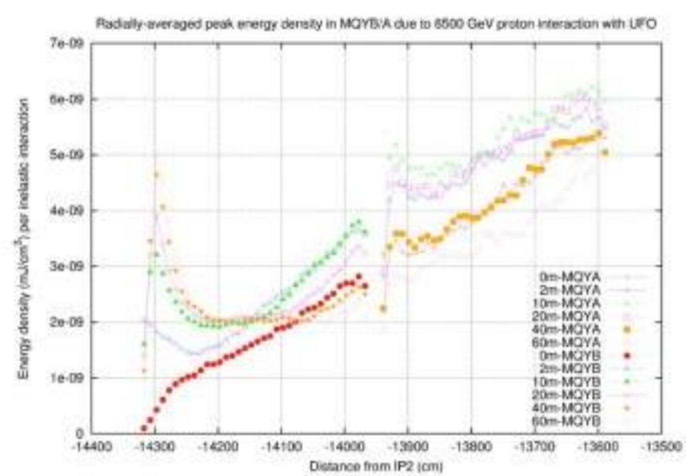




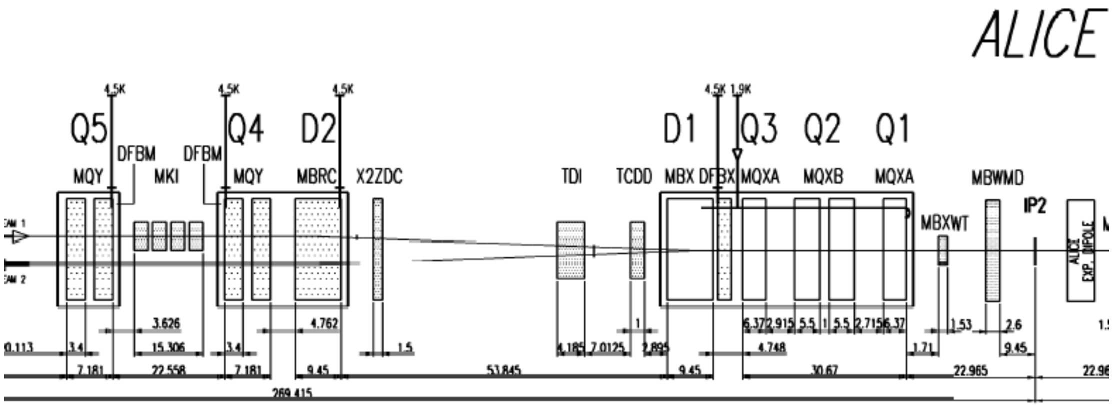




$$\text{BLMSignal@Quench}(E,t) = \frac{\text{BLMResponse}(E,t) * \text{QuenchLevel}(E,t)}{\text{EnergyDeposit}(E,t)}$$

MBX (MBRC) UFO

UFOs are simulated in different locations upstream of the MBX 3L2. Thresholds are computed for the **0-m-location**, as otherwise they would be exceedingly large.



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

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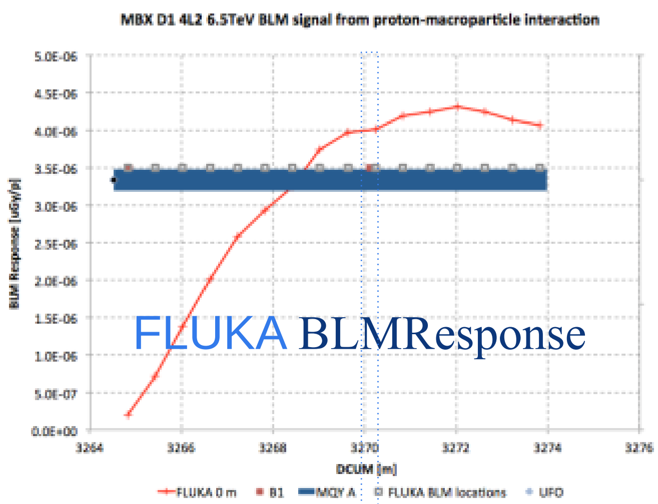

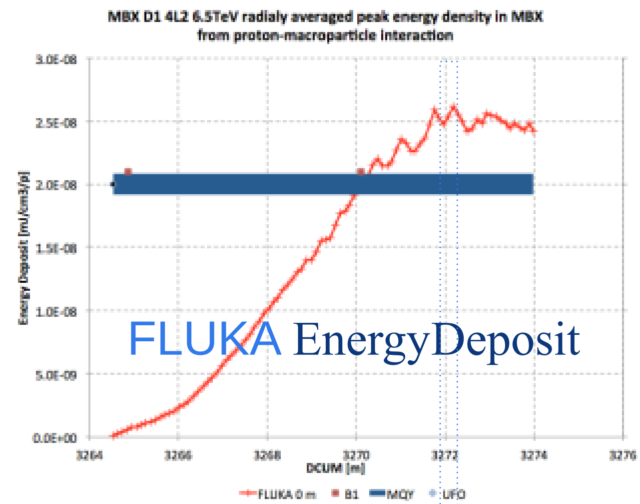

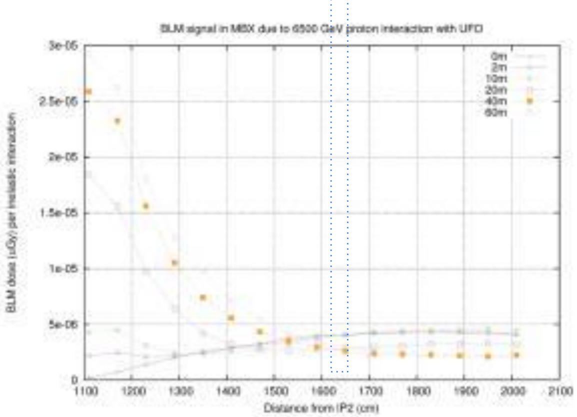

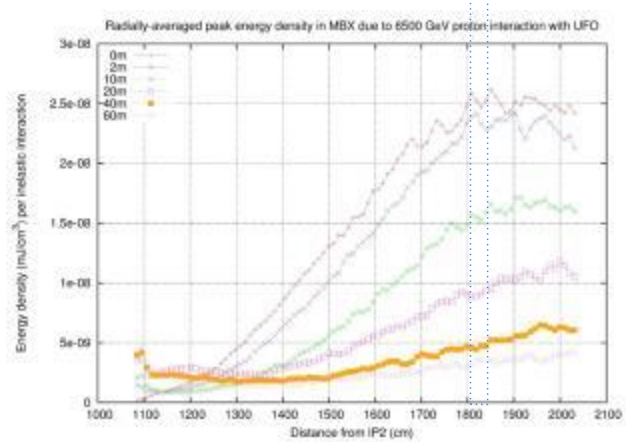

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SS Thresholds

all position-3 BLMs on IPQs are set to maximum.

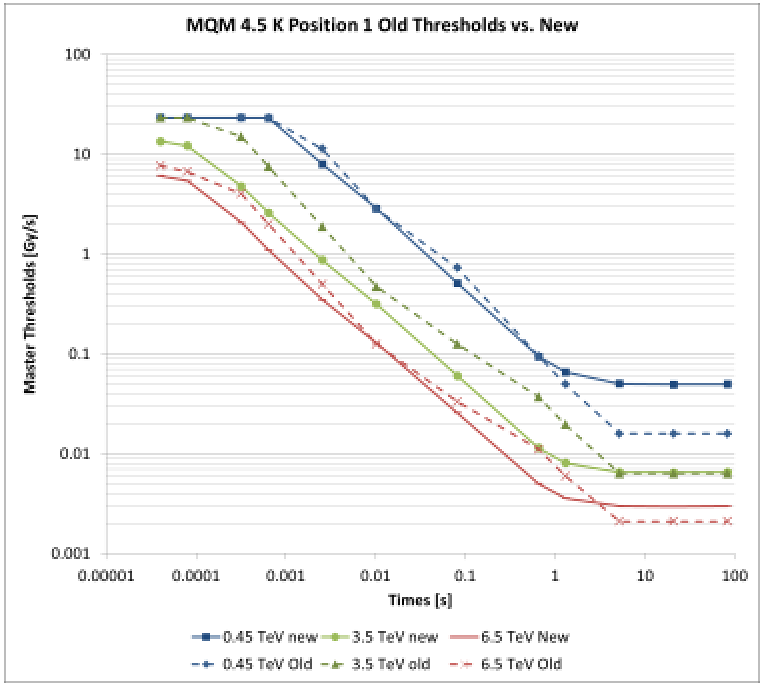
Large uncertainties on BLM locations.

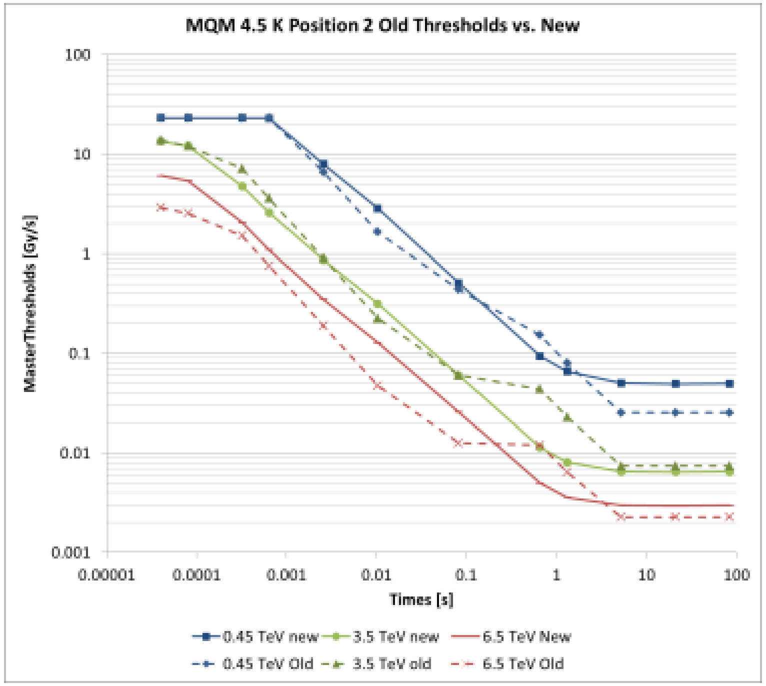
MQM 4.5 K Positions 1,2

DOB. Pos. 1 and 2 thresholds identical (Position 1 sees little signal from DOB)

Old thresholds:

- Energy Deposit and BLM Response: C. Kurfürst "TWISS" scenario (Losses at interconnect).
- Quench Level: MQM Note 44 / 4.5 K strand enthalpy and 1.9 K steady-state limit.



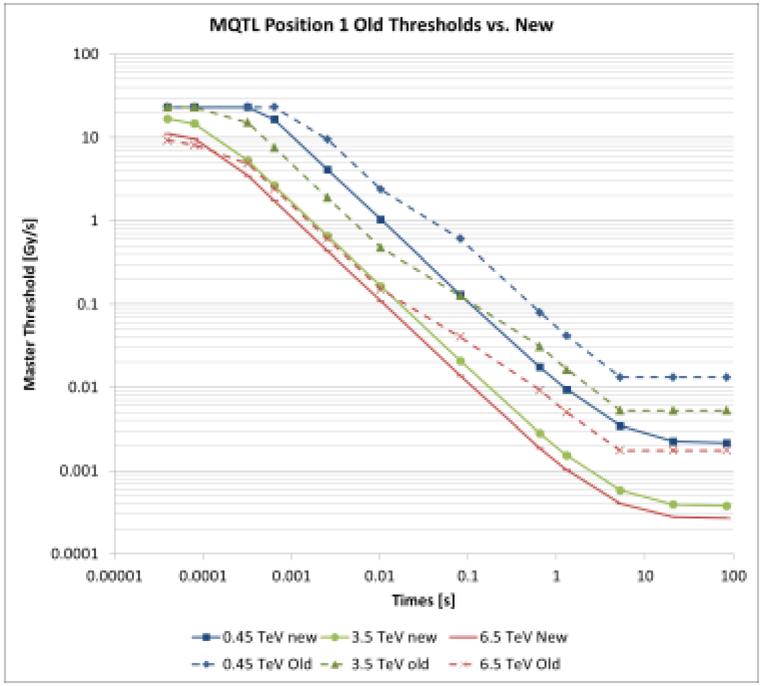


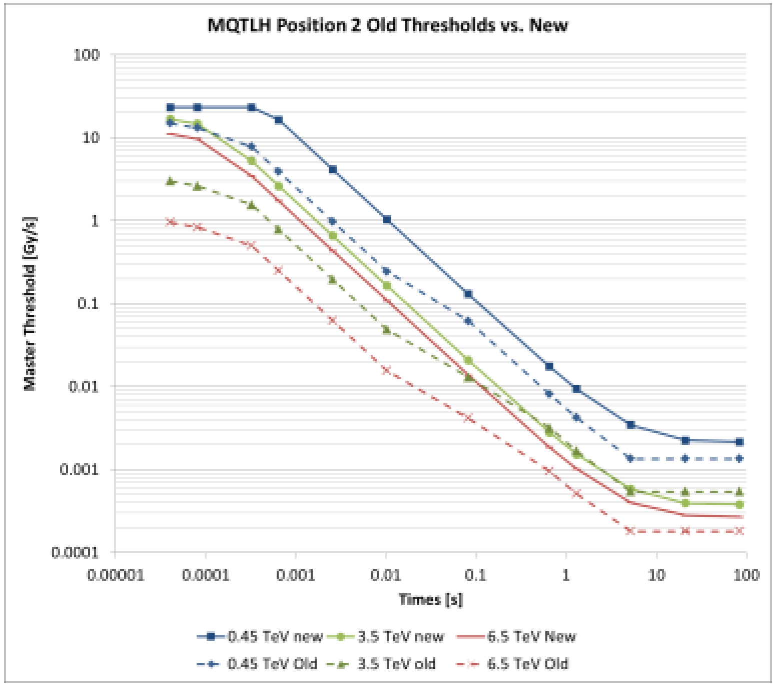
MQTL 4.5 K Positions 1,2

DOB. Pos. 1 and 2 thresholds identical (Position 1 sees little signal from DOB)

Old thresholds:

- Energy Deposit and BLM Response: C. Kurfürst “TWISS” scenario (Losses at interconnect).
- Quench Level: MQY Note 44 with D. Bocian values.

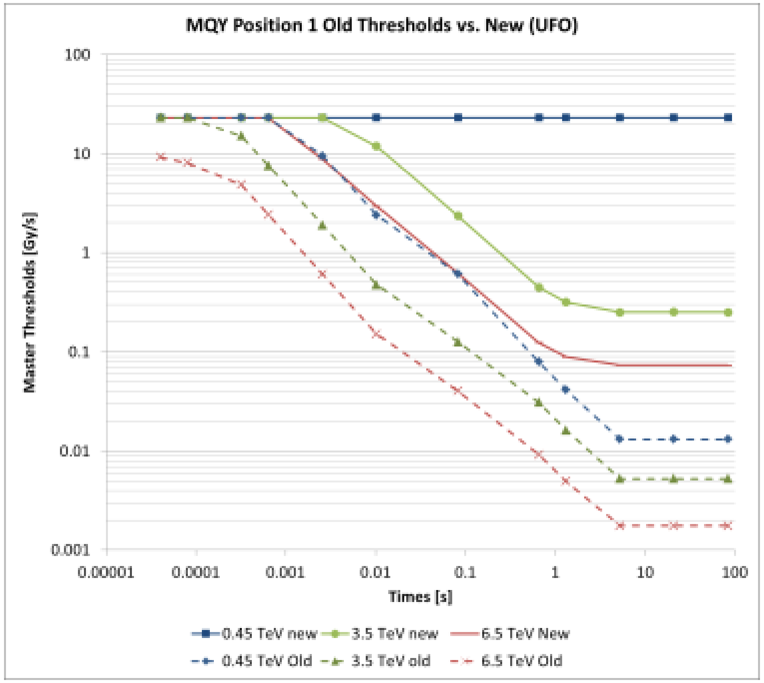


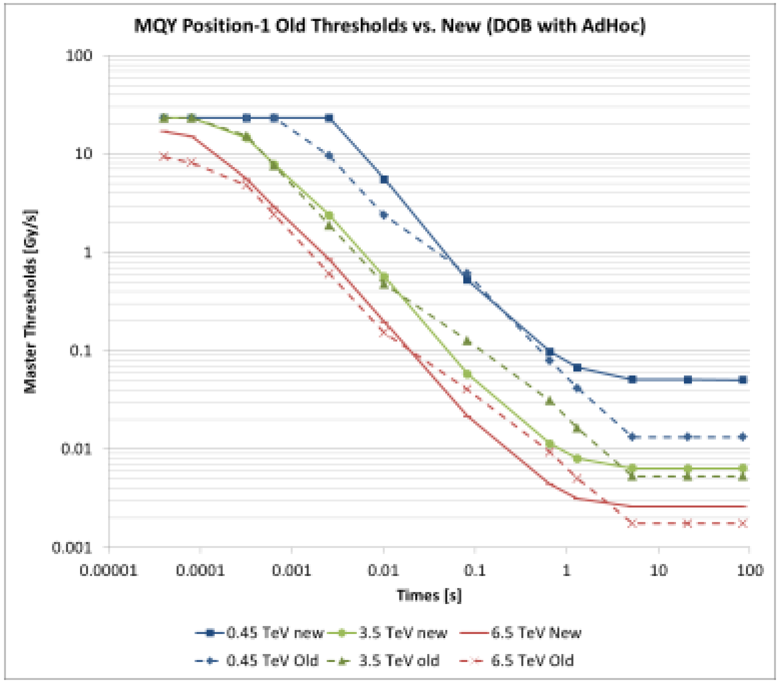


MQY 4.5 K Position 1

UFO vs. DOB.

Proposition: Use DOB with AdHoc factors (see next slide).



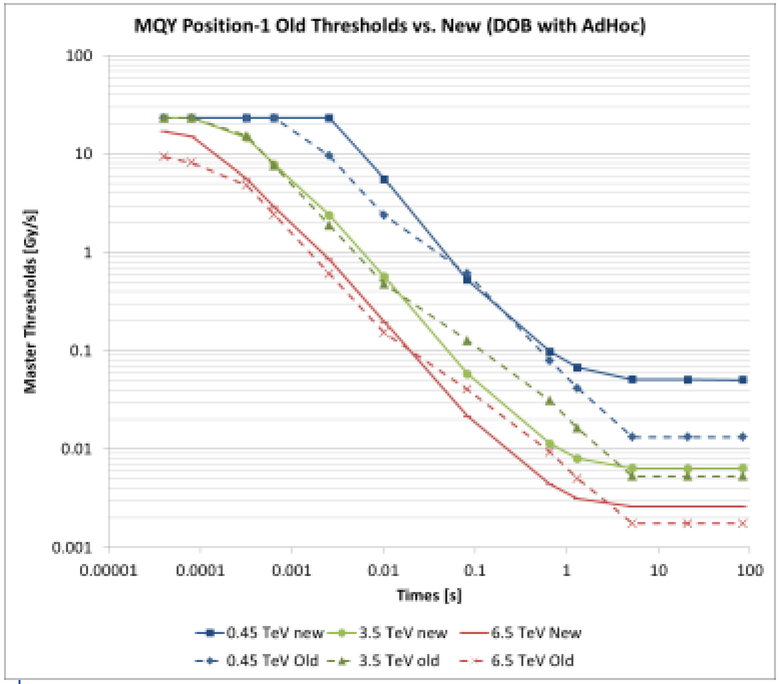


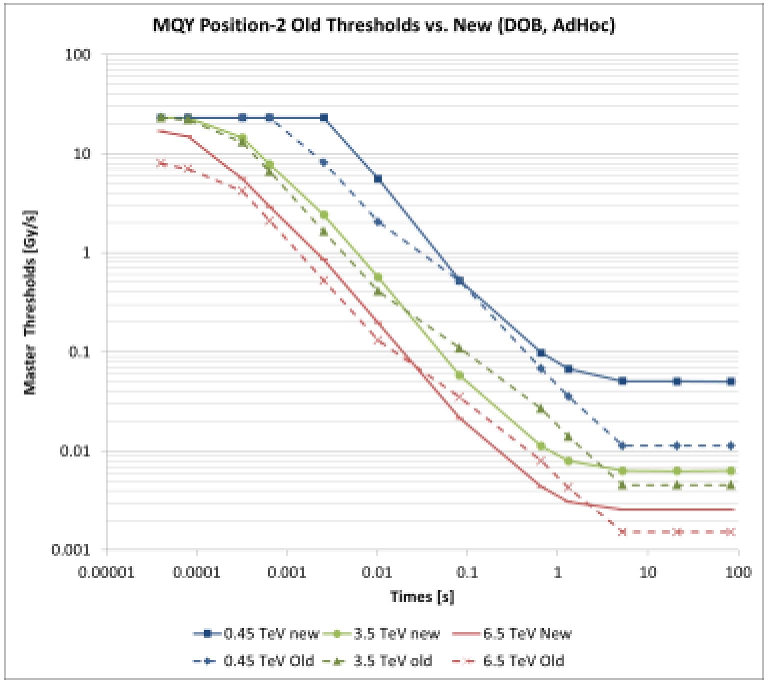
MQY 4.5 K Positions 1,2

DOB with AdHoc factors. (RS1-5: 3, RS6: 2) Note that there should be room for a further increase in AdHoc factors to accommodate MKI UFOs.

Old thresholds:

- Energy Deposit and BLM Response: C. Kurfürst “TWISS” scenario (Losses at interconnect).
- Quench Level: MQY Note 44 / D. Bocian parameters.



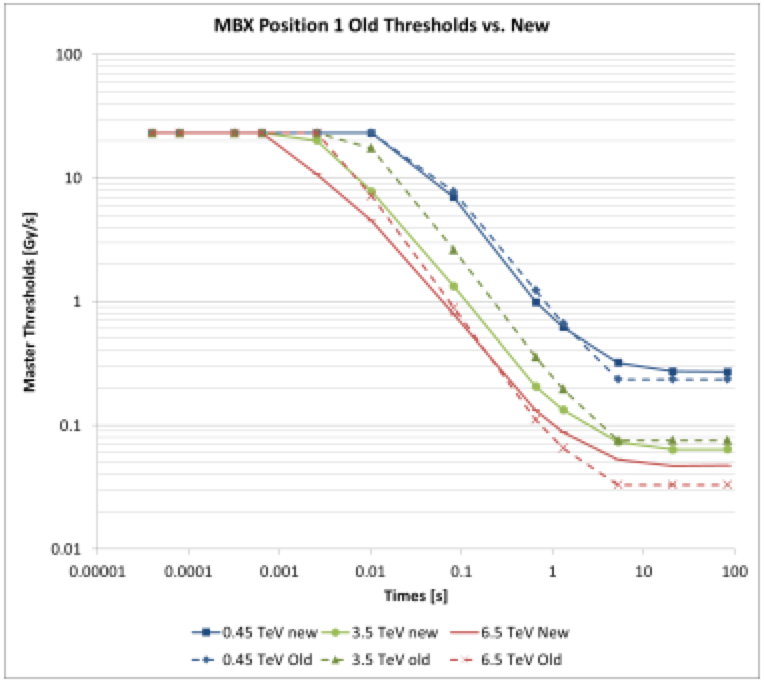


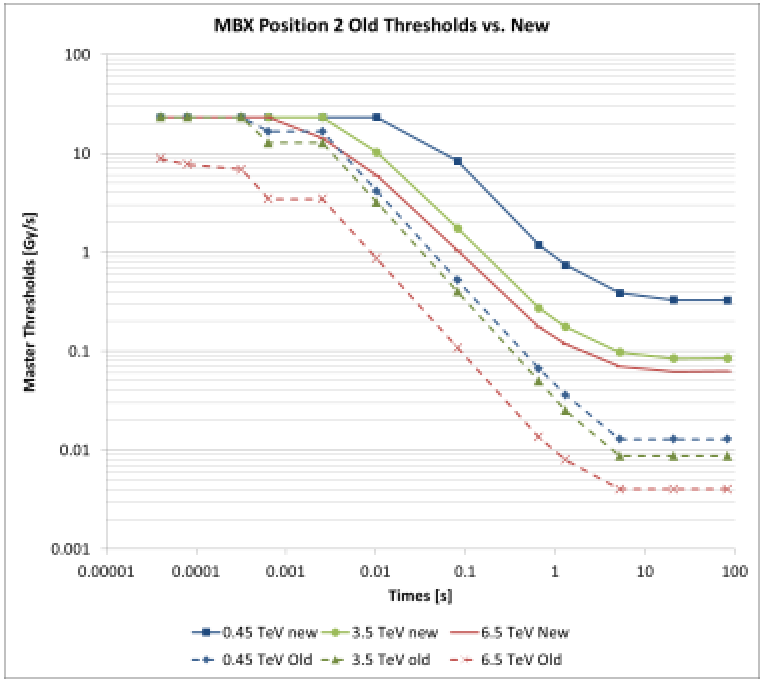
MBX 1.9 K Positions 1,2

UFO location selected as to reproduce roughly old thresholds!

Old thresholds:

- Energy Deposit: Position 1: Note 422 MB (Strong-kick event),
  Position 2: C. Kurfürst "TWISS" scenario (Losses at interconnect)
- BLM Response: C. Kurfürst "TWISS" scenario (Losses at interconnect).
- Quench Level: MBX = 2x MB.



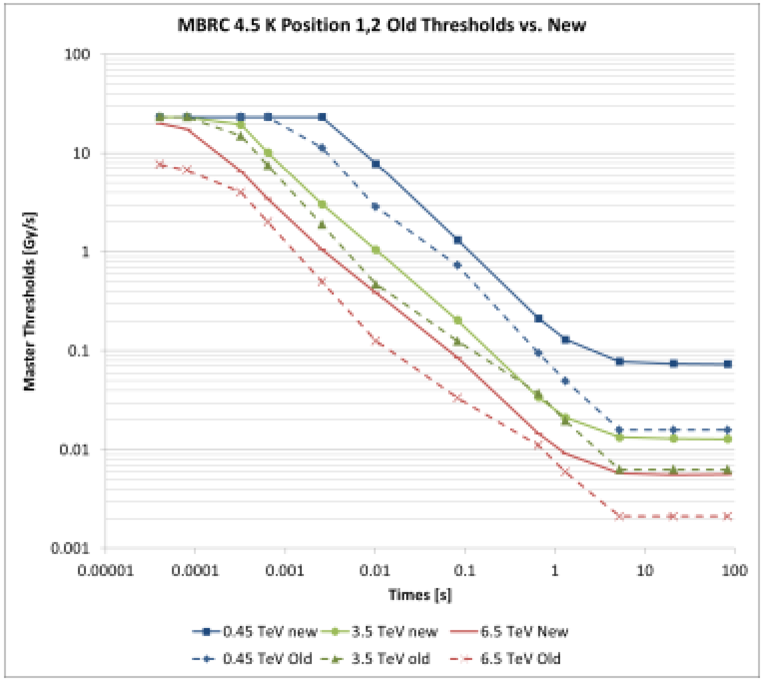


MBRC 4.5 K Positions 1,2

UFO location selected as to reproduce roughly old thresholds!

Old thresholds:

- Energy Deposit and BLM Response: C. Kurfürst “TWISS” scenario (Losses at interconnect).
- Quench Level: MQM 4.5 K Note 44 / D. Bocian parameters.



Summary

- Use of Orbit Bump scenario for all LSS Quadrupoles
- MQY thresholds raised with Adhoc factors to be above the run1 thresholds.
- All magnets at 4.5K apart from MQYs don’t have Adhoc factors, i.e. equal to 1.
- MBX, MBRC UFO location set to reproduce roughly the old thresholds.
- BLMs in position 1 have the same thresholds as position 2
- BLMs in position 3 are set to maximum

Thanks for your attention!

Spare slides

Slides from B.Auchmann 4th BLMTWG meeting

$$\mathrm{MasterThreshold}(E,t) \cong \boxed{N} * \mathrm{BLMSignal@Quench}(E,t) * \mathrm{AdHoc}(t)$$

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

Paths (not) chosen: the N and MonitorFactor

The N factor is hard-coded to equal 3 in the new tool and cannot be used for convenience.

The MonitorFactor will be set to 0.33 in the arc and DS sections, and to 0.1 elsewhere (comment of J.P. Tock at Chamonix on the availability of spares).

MPP 14/06/26

> **Default Monitor Factor / Which *N* should be choose?**
>
> - Low enough to protect from damage.
> - High enough to allow for timely adjustments, e.g., in case of new relevant loss scenario.
> - Proposal: *N* = 10 (instead of 3 pre LS1).

$$\mathrm{MasterThreshold}(E,t) \cong N * \mathrm{BLMSignal@Quench}(E,t) * \boxed{\mathrm{AdHoc}(t)}$$

Paths (not) chosen: AdHoc corrections

AdHoc accounts for missing features/inaccuracies in the numerical models.

The electro-thermal model underestimated the quench level for the intermediate-loss orbit-bump quench test at 1.9 K (ADT).

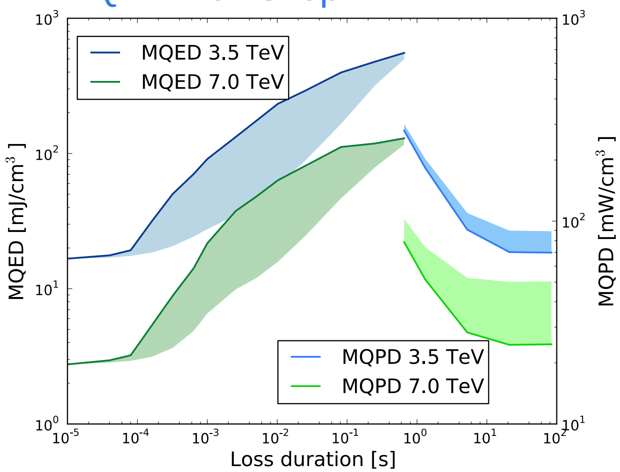
This might be due to the spiky sub-structure of the losses, in which case the factor should apply also to faster RSs.

The only faster quench test produced single-turn losses.

For all magnets at 1.9 K we correct the quench levels!

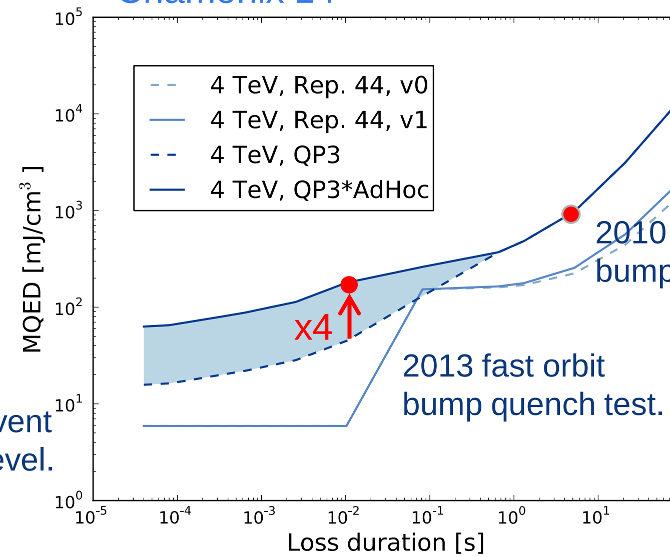
In the arcs his may lead to a few beam-induced quenches until we get the factors right.

BIQ14 Workshop



2008 strong-kick event validated quench level.

Chamonix 14



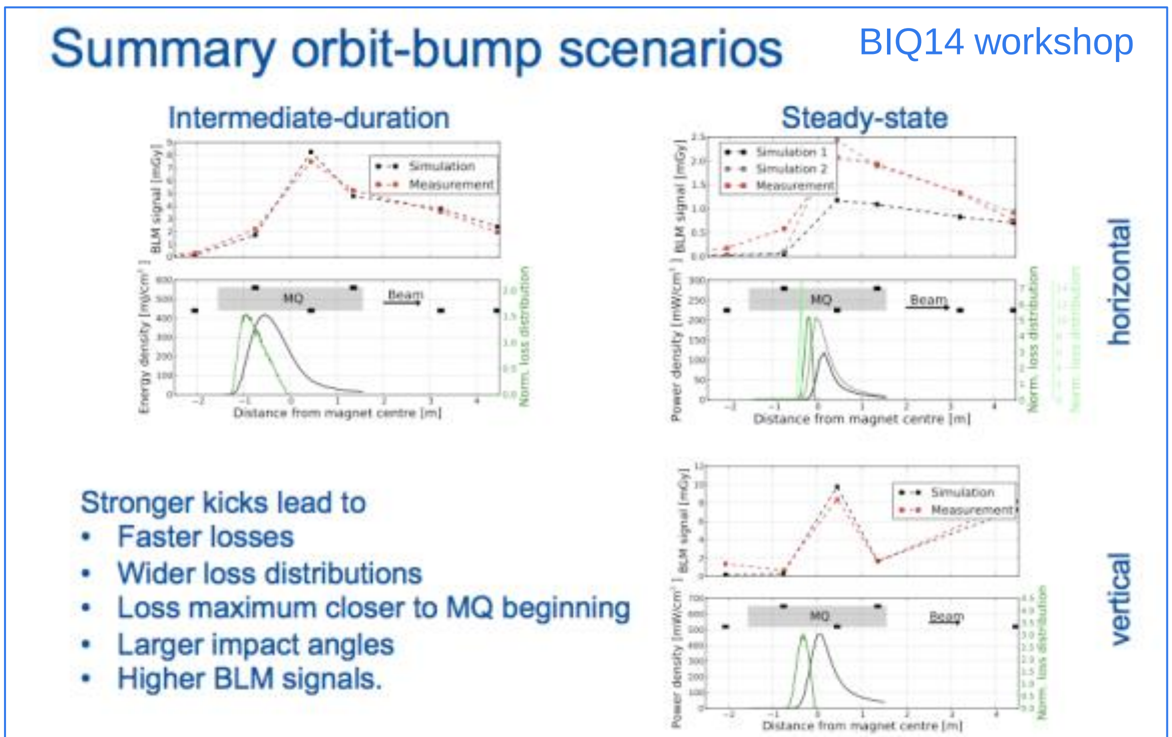
$$\mathrm{BLMSignal@Quench}(E,t) = \frac{\mathrm{BLMResponse}(E,t) * \mathrm{QuenchLevel}(E,t)}{\mathrm{EnergyDeposit}(E,t)}$$

Paths (not) chosen: Which orbit bump?

No ONE orbit-bump scenario can accurately predict all RSs. Loss distribution depends on loss duration.

For orbit-bump-type losses we select the vertical orbit-bump scenario of the 2010 dynamic-orbit-bump quench tests (DOB).

Applied in MQ position 3, IPQs, Q1/3, MQW.



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

Paths (not) chosen: SS heat-transfer models

Based on steady-state orbit-bump quench test (ADT) analysis we select the more conservative empirical model for MB and MQ.

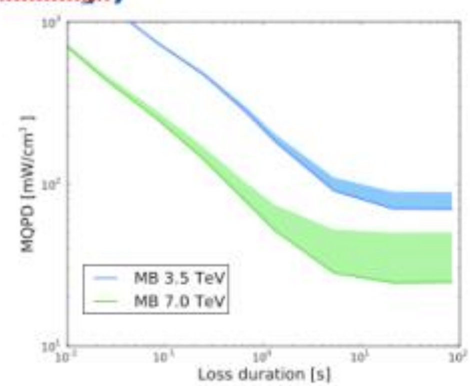
The model still gives much higher estimates than previously used.

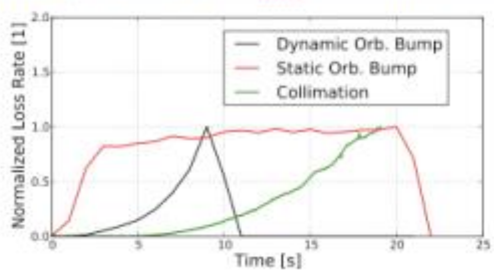
Steady-state losses (5 s – infty)

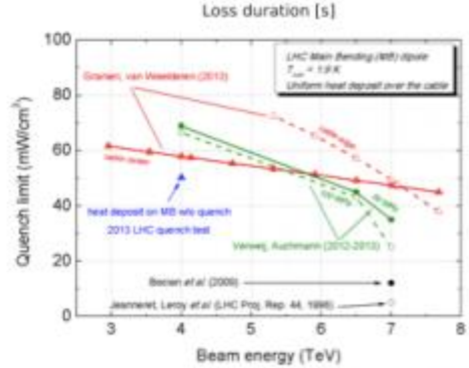
BIQ14 workshop

- Uncertainties due to “fish-bone” are more important at higher energies.
- Definitive validation not possible at 4 TeV.
- Based on static-orbit bump QT results we use the more conservative assumption.
- More input in tomorrow’s morning session!

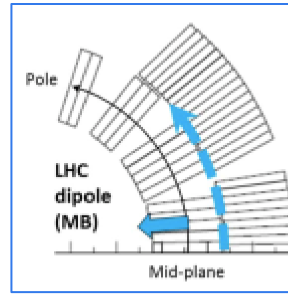
Test	Energy [TeV]	Type	Ramp time [s]	MQPD [mW/cm³]	FLUKA [mW/cm³]
Dyn. Orbit Bump	3.5	MQ	6	180^{+35}	208
Collimation	4	MB	15	115^{+25}	n/a
Static Orbit Bump	4	MQ	infty	70^{+18}	41^{+33}





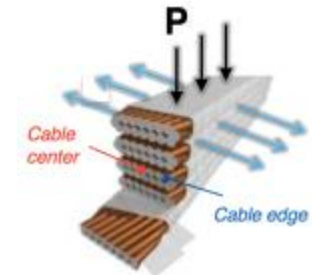


Courtesy P.P. Granieri



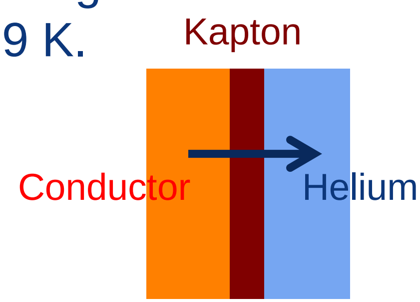
$$\mathrm{BLMSignal@Quench}(E,t) = \frac{\mathrm{BLMResponse}(E,t) * \mathrm{QuenchLevel}(E,t)}{\mathrm{EnergyDeposit}(E,t)}$$

Paths (not) chosen: SS heat-transfer models

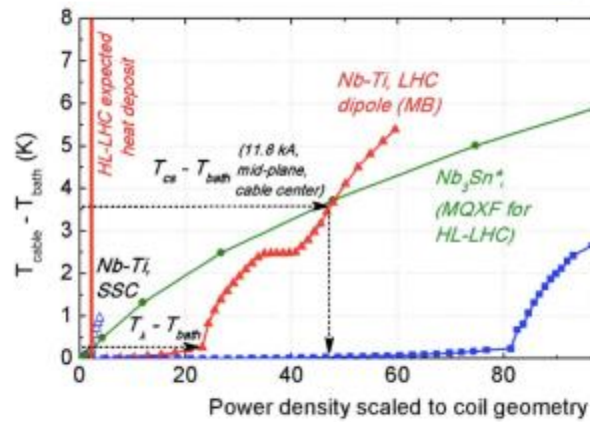


In an attempt to be consistent with below literature we propose:

- MQXA and MQXB get conservative bulk-insulation model.
- MQM at 1.9 K get the MB/MQ empirical model.
- At 4.5 K (MQM, MQY, MQTL) the bulk-insulation model is used.
- MQTL would get the bulk-insulation mode even at 1.9 K.



Bulk-insulation model



Empirical model

R. Ostojic, Insertion Magnets and Beam Heat Loads, at workshop "Beam generated heat deposition and quench levels for LHC magnets", 3-4 March 2005

I. Novitski and A. V. Zlobin. Thermal analysis of SC quadrupoles in accelerator interaction regions. IEEE Transactions On Applied Superconductivity, 17(2):1059–1062, June 2007.

L. Chiesa, S. Feher, J. Kerby, M. Lamm, I. Novitski, D. Orris, J. P. Ozelis, T. J. Peterson, M. Tartaglia, and A. V. Zlobin. Thermal studies of a high gradient quadrupole magnet cooled with pressurized, stagnant superfluid. IEEE Transactions on Applied Superconductivity, 11(1):1625–1628, March 2001.

N. Kimura, A. Yamamoto, T. Shintomi, and A. Terashima. Heat transfer characteristics of Rutherford- type superconducting cables in pressurized He II. IEEE Transactions on Applied Superconductivity, 9(2):1097–1100, June 1999.

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