



6th BLM Thresholds WG Meeting, February 10, 2015

BLM Thresholds for the Inner Triplets

Ondřej Pícha



Overview

- Inner triplet, BLMs, families
- Luminosity debris
- IT loss scenarios
 - Q2B loss
- BLM thresholds and families
 - Proposed strategy
 - Changes in families
 - Old and new threshold comparison



BLM Threshold Formula

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

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

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

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.

- For cold magnets: $N = 3$, MonitorFactor = 0.3 in arcs, 0.1 for IPQs/IPDs.



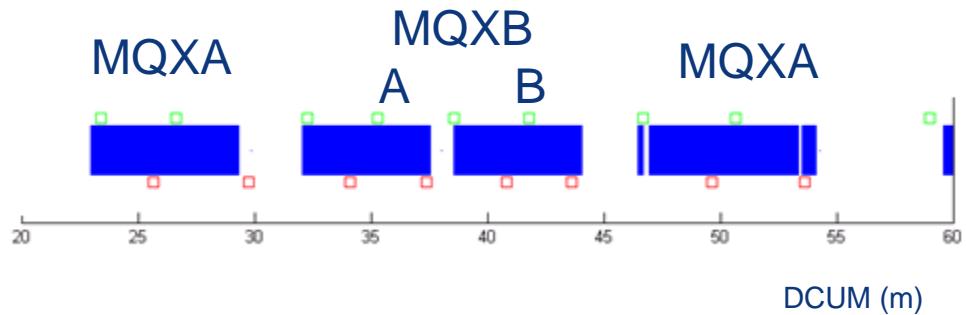
BLMs on the IT



- Each triplet:
18 BLMs (B1&B2)
Grouped for Run 1 into
12 families (B1 and B2 separate families)

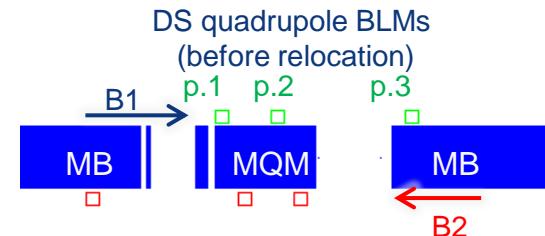
- All IT:
16 BLM families with
144 monitors (2 injection families included)

right from IP1

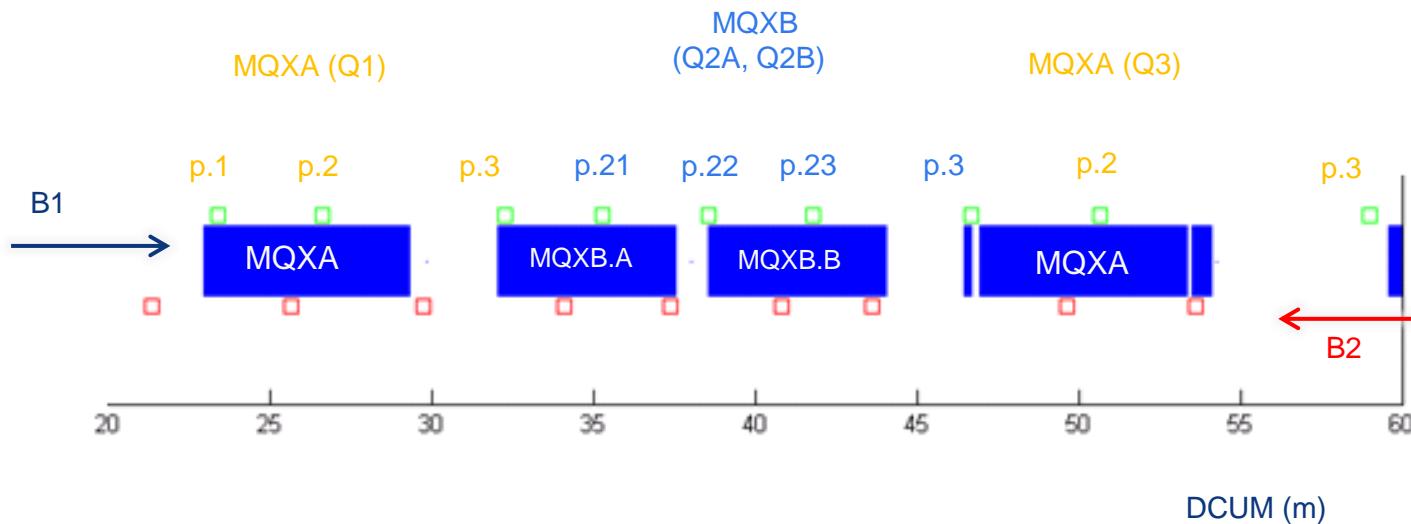


BLMs on the IT - Naming

- BLMs position similar as on quads
- BLM positions are the same for all the ITs

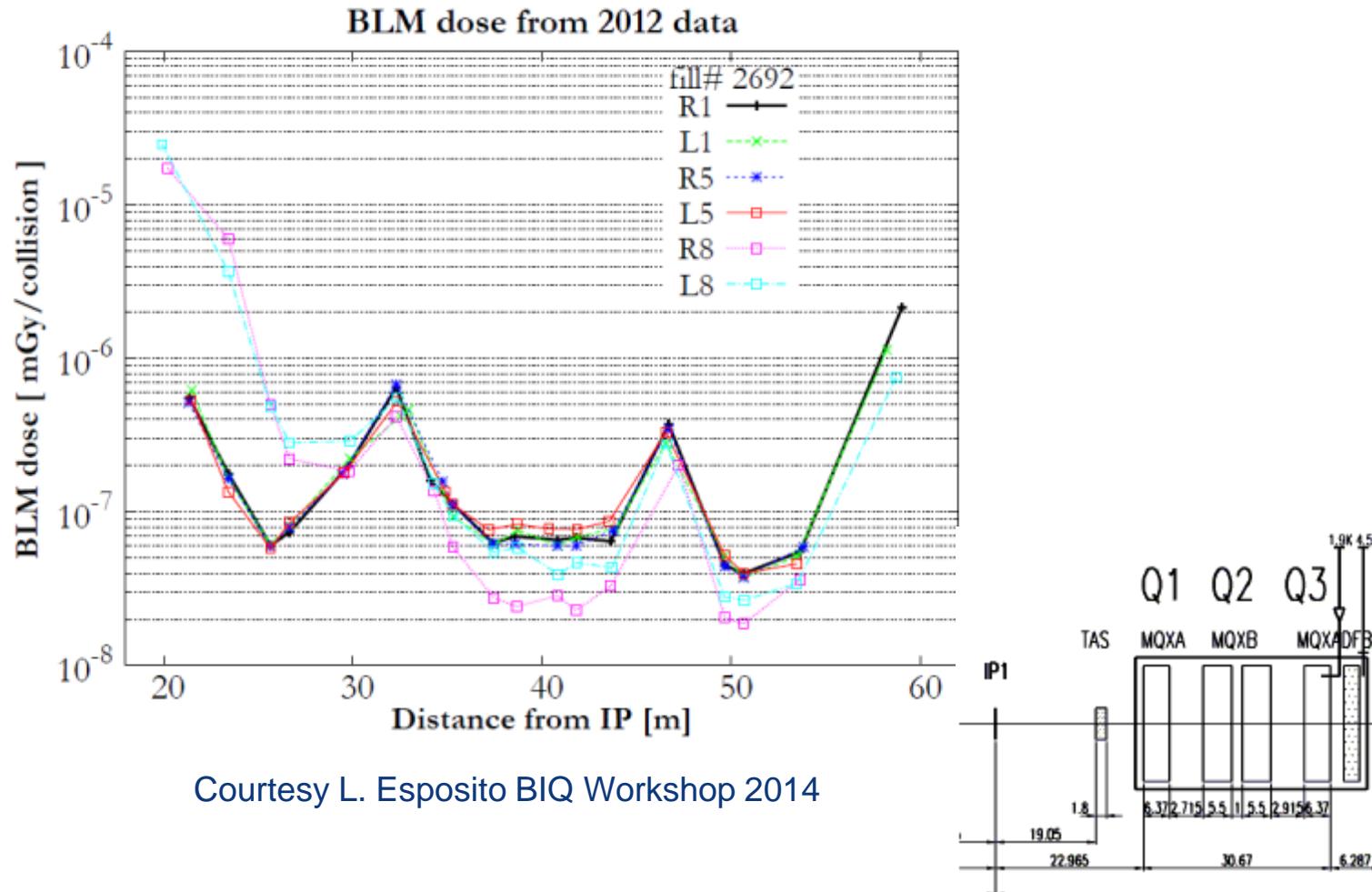


Right from IP1



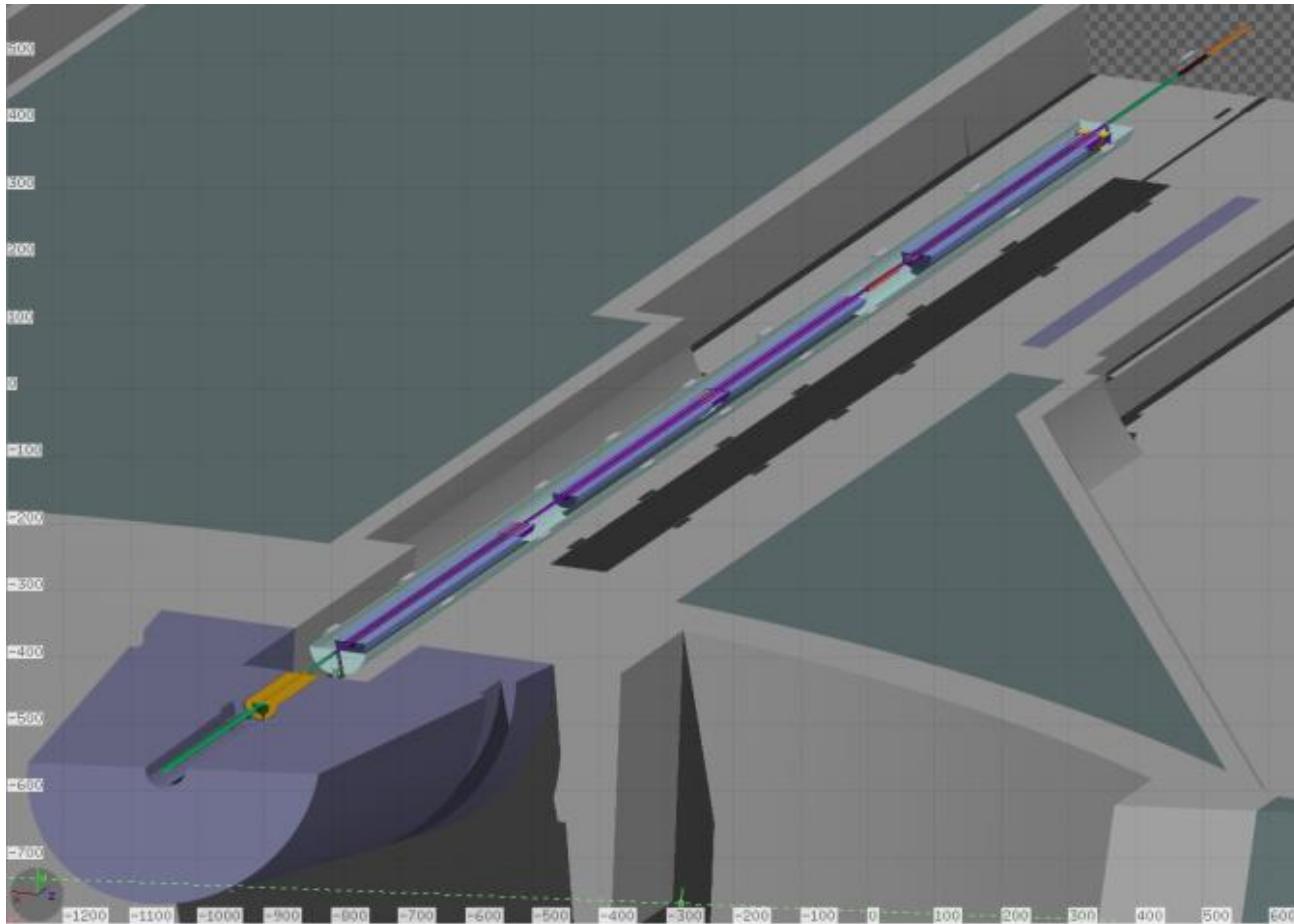
Luminosity Debris – Measured Data

- BLM signals similar for P1 and P5
- Difference in P2 and P8 due to the absence of the TAS



Luminosity Debris – FLUKA Model

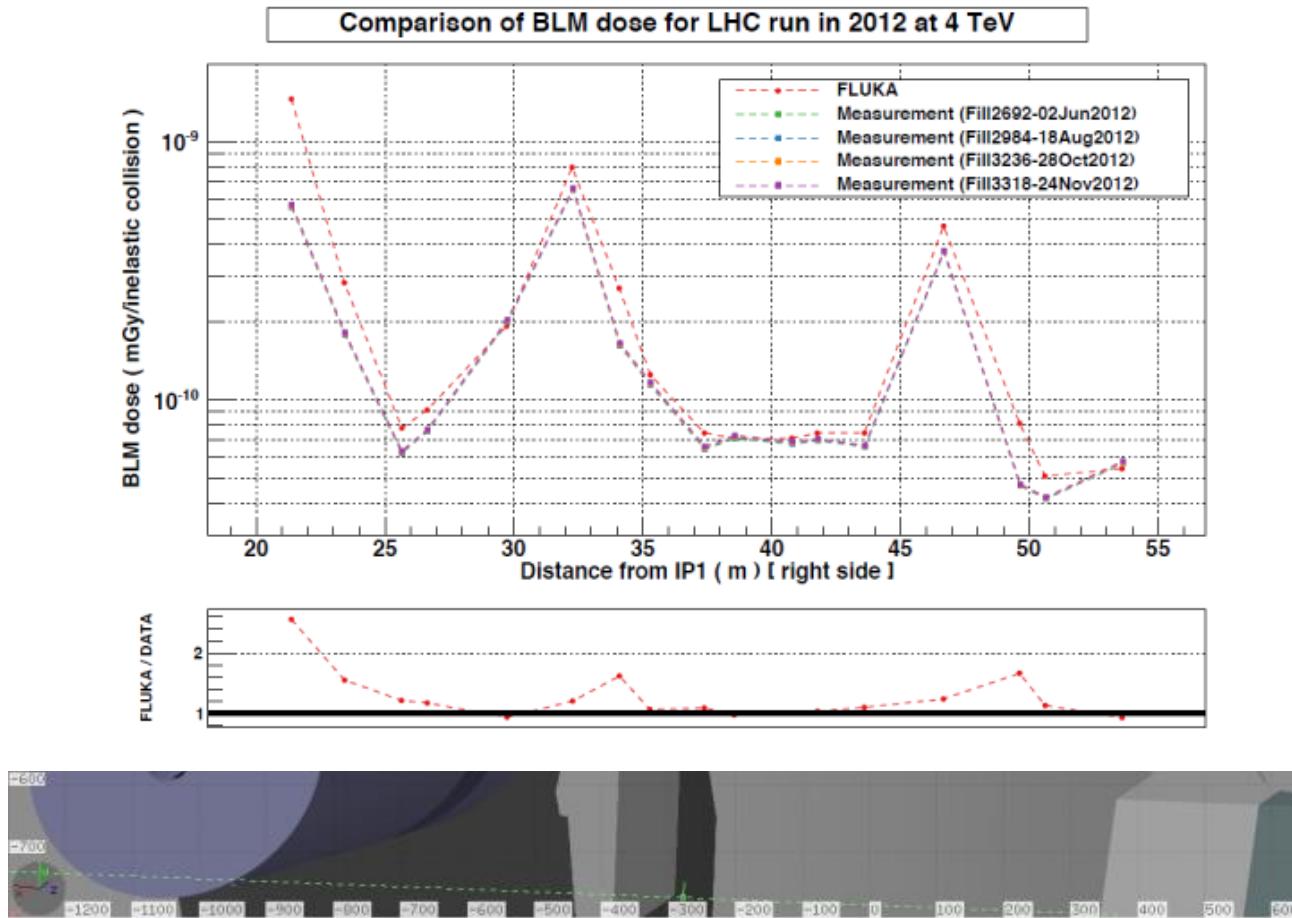
- FLUKA model of the right side of the IP1 tunnel



Courtesy L. Esposito BIQ Workshop 2014

Luminosity Debris – FLUKA vs. Measurement

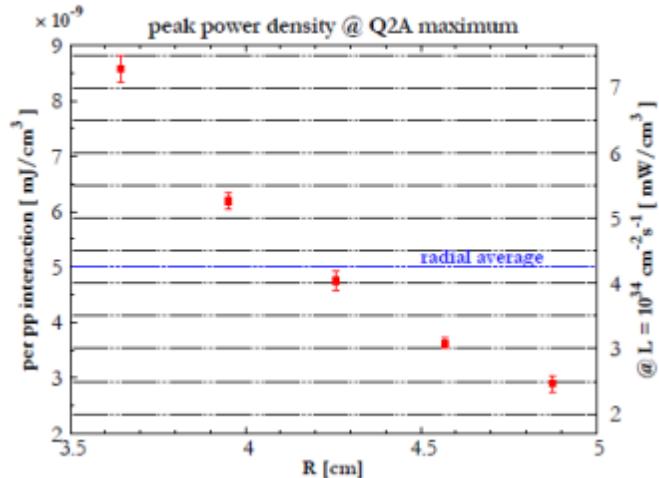
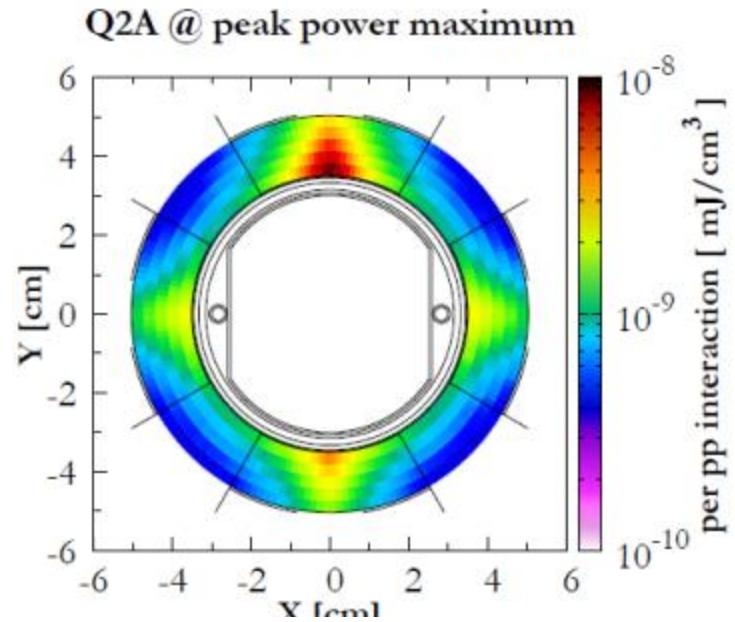
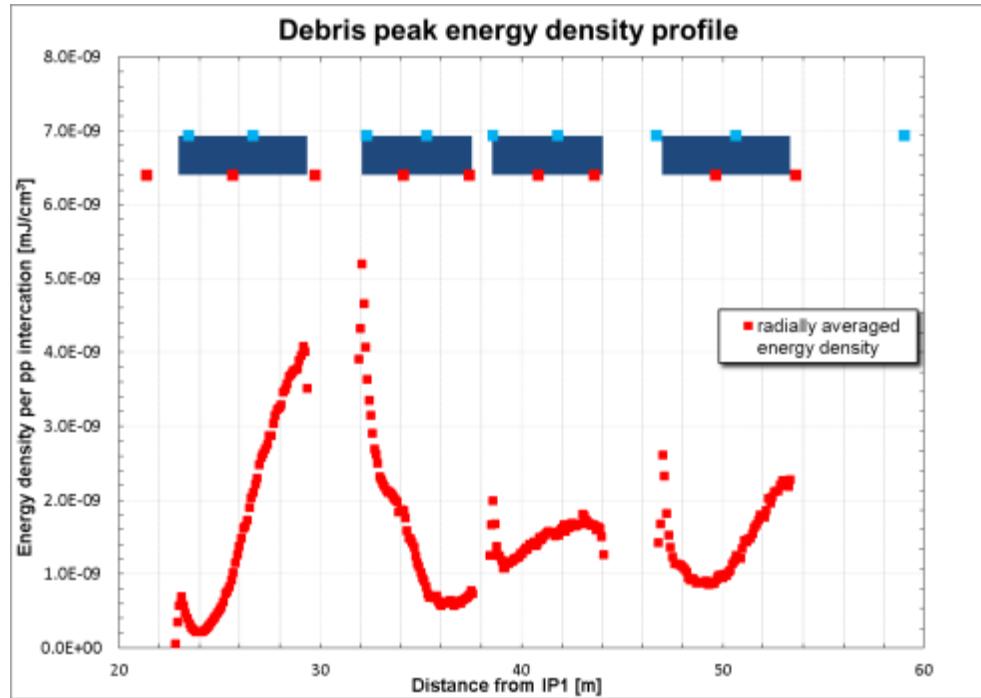
- FLUKA model of the right side of the IP1 tunnel



Courtesy L. Esposito BIQ Workshop 2014

Luminosity Debris

6.5 TeV simulation.



Courtesy L. Esposito BIQ Workshop 2014



IT – Quench Level

- Quench level calculated using QP3 – bulk insulation model at 1.9K
- Model is now in good agreement with published data (which remains valid until we have a quench/quench test!).

Magnet	MQPD	Luminosity 1E+34		Luminosity 1.75E+34	
		[cm ⁻² ·s ⁻¹]		[cm ⁻² ·s ⁻¹]	
		DPD	ratio DPD/MQPD	DPD	ratio DPD/MQPD
		[mW/cm ³]	[mW/cm ³]	[mW/cm ³]	-
MQXB	13.05	4.43	0.34	7.75	0.59
MQXA	33.18	3.40	0.10	5.95	0.18

MQPD – minimum quench power density

DPD – debris power density

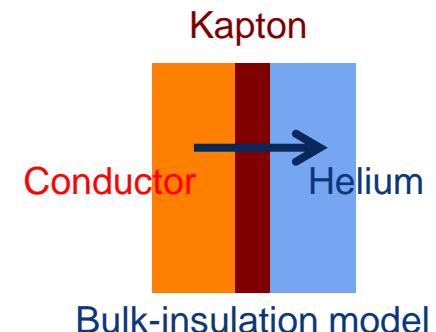
Luminosity:

1e34 – nominal for IP1 and IP5

1.75e34 - from Laurent Tavian at Evian 2012 -

limitation from the consolidation of the heat exchanger following the "triplet incident" during initial commissioning

- Luminosity debris can not quench the magnets at 6.5 TeV
- Different loss scenario needed for the BLMs



L. Chiesa et al. "Thermal Studies of a High Gradient Quadrupole Magnet Cooled with Pressurized, Stagnant Superfluid," *IEEE Trans. on Applied Superconductivity*, Vol. 11, Issue 1 , March 2001, p.1625.

IT Beam Loss Scenarios

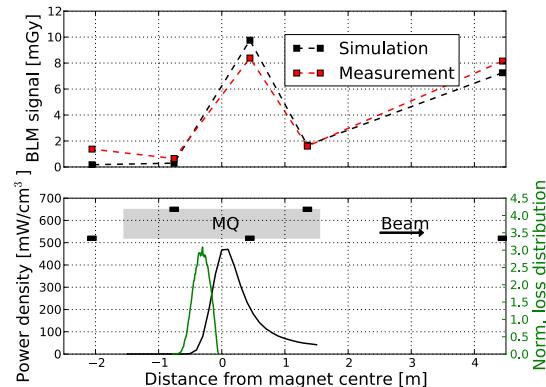
MQXB:

- Q2B loss scenario – wrong collimators setting in the IR7 or retracted TCT. Described in the CERN-ATS-Note-2012-014 TECH

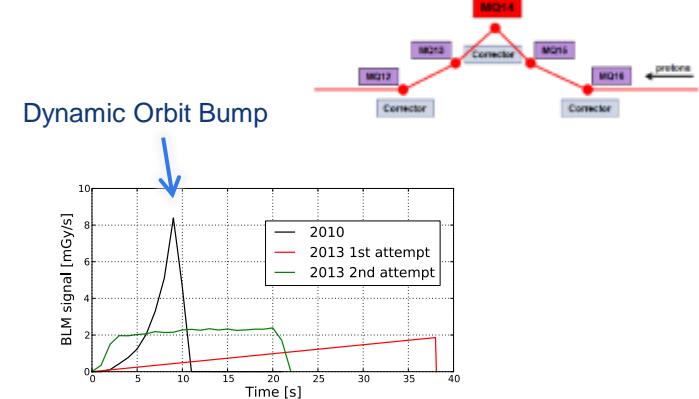
MQXA:

- UFOs proven to be not limiting for the IPQs at 4.5 K (5th BLMTWG meeting slides)
- Dynamic orbit bump - Not a “real” scenario, but leads to the thresholds settings in a reasonable range.
 - Used in the ARC and DS – position 3* monitor, IPQs – all 3 BLMs (position one monitor has the same thresholds as the position 2)
 - * ... position formerly known as position 3.

FLUKA
BLMResponse

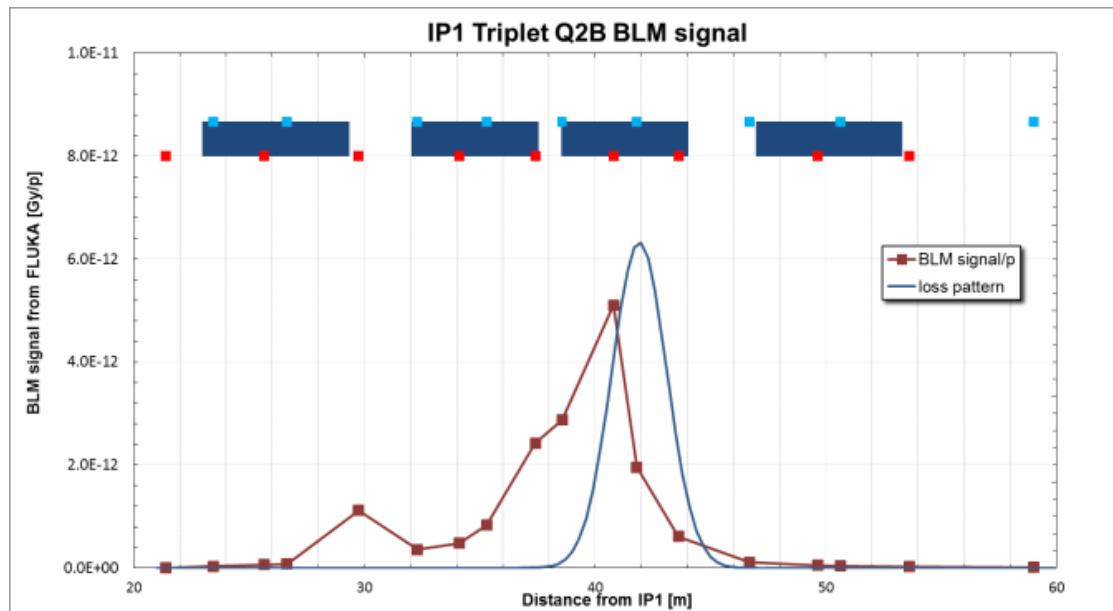


FLUKA
EnergyDeposit



Q2B Loss Scenario

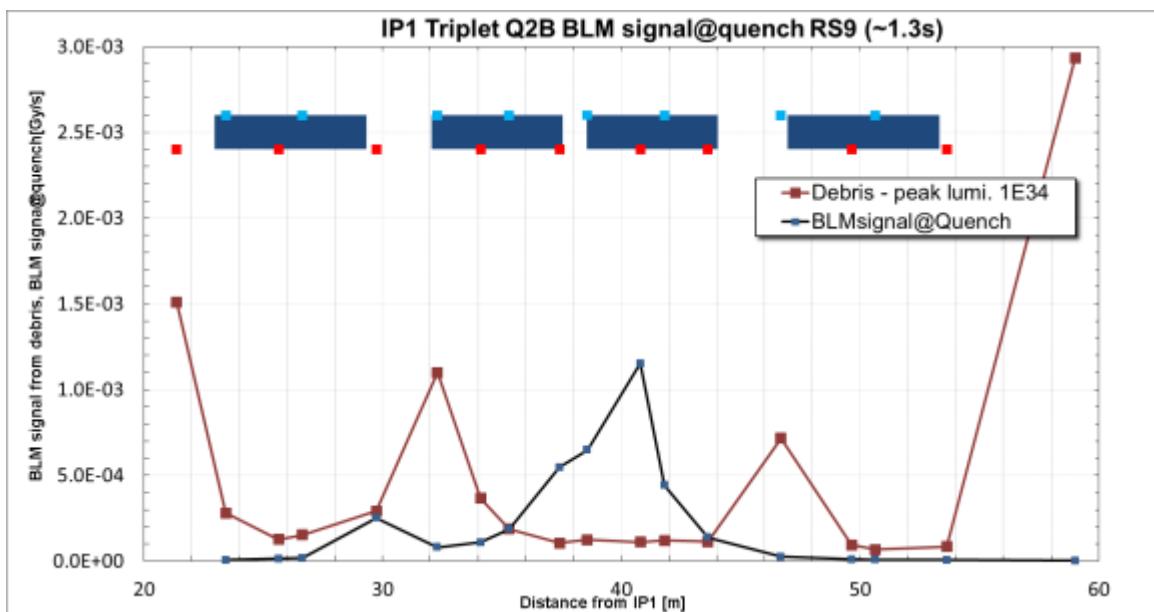
- CERN-ATS-Note-2012-014 TECH – beam loss at 7 TeV
- For purpose of this study BLM signal rescaled to 6.5 TeV
- 3 downstream BLMs on the Q2 measure the highest signal



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

Q2B Loss Scenario – BLM Signal at Quench

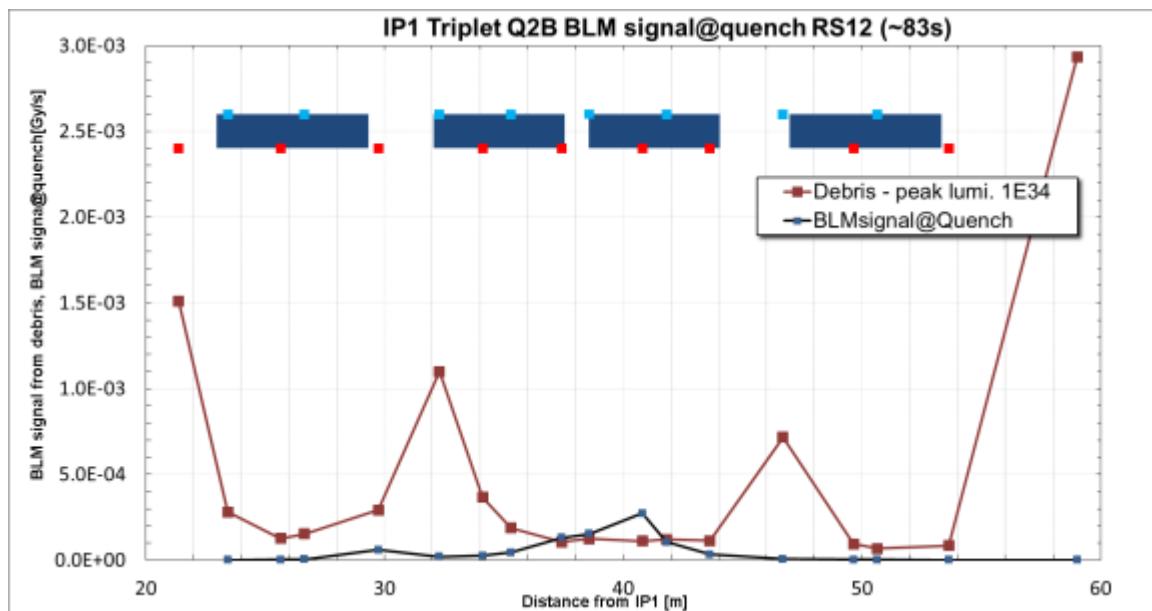
- BLM signal at quench is higher than the debris on 3 monitors in RS9
- Debris BLM signal for the peak luminosity 1e34



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

Q2B BLM Signal at Quench vs. Debris

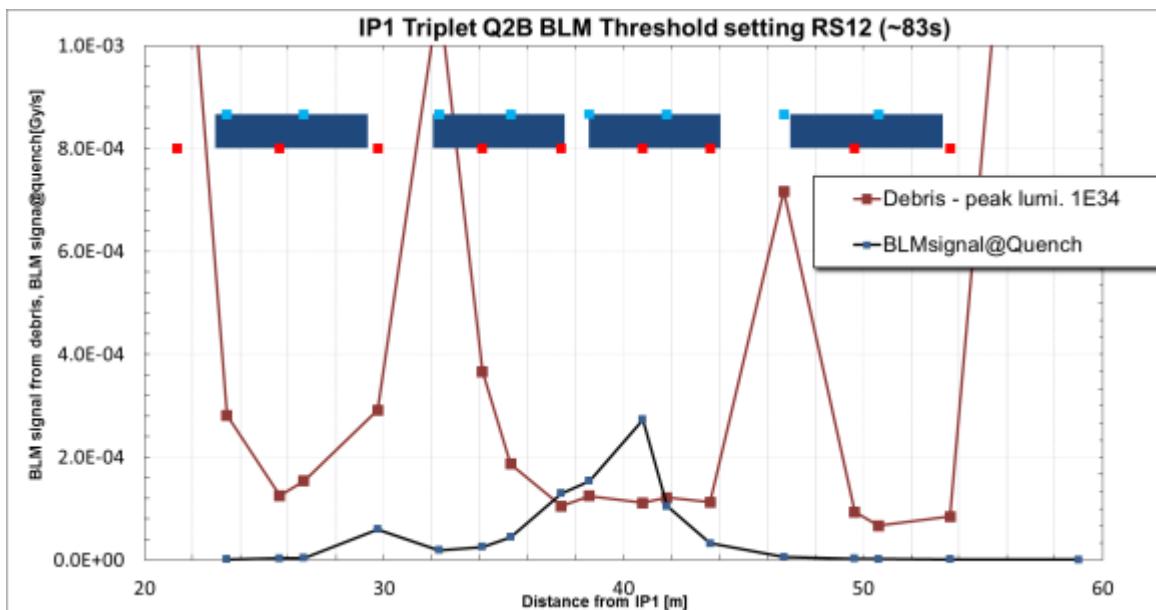
- BLM signal at quench is higher than the debris on 3 monitors in RS12



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

Q2B BLM Signal at Quench vs. Debris

- BLM signal at quench is higher than the debris on 3 monitors in RS12
 - Monitor factor set to be 0.166 i.e. factor 2 under the predicted quench level
- Applied Threshold = $0.5 \cdot \text{BLMSignal}@{\text{Quench}}$



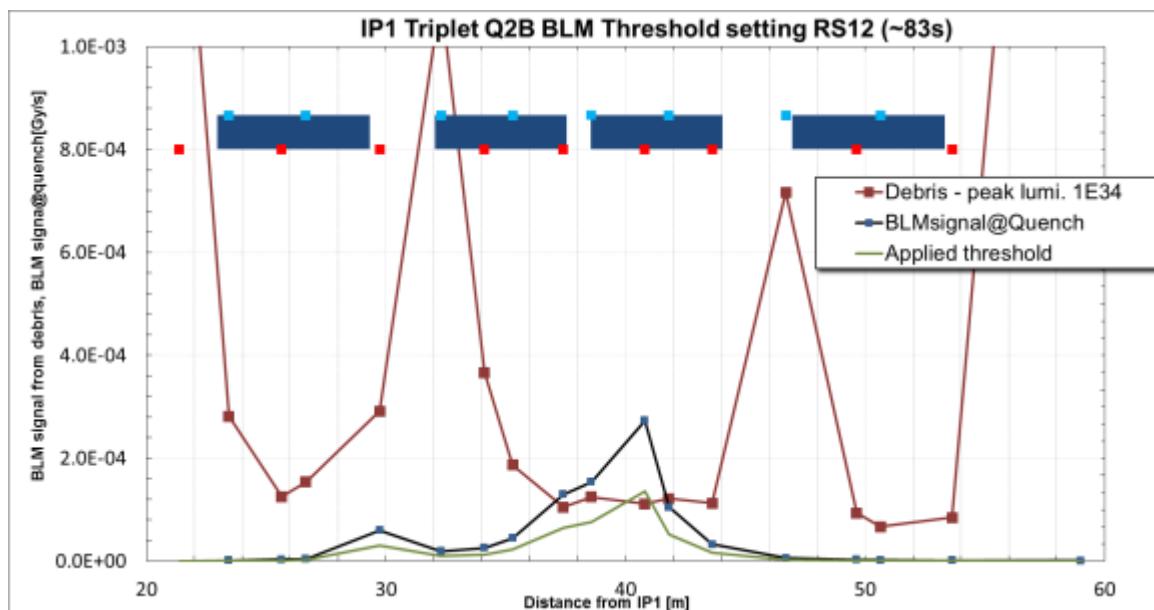
$$\text{BLMSignal@Quench}(E, t) = \frac{\text{BLMResponse}(E, t) * \text{QuenchLevel}(E, t)}{\text{EnergyDeposit}(E, t)}$$

Q2B loss scenario – BLM signal at quench

- Monitor factor set to be 0.166 i.e. factor 2 under the predicted quench level
- One should assure that BLMs are not in the warning level (30% of the threshold)

Applied Threshold = $0.5 \cdot \text{BLMSignal@Quench}$

Warning level = $0.3 \cdot \text{Applied Threshold}$



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

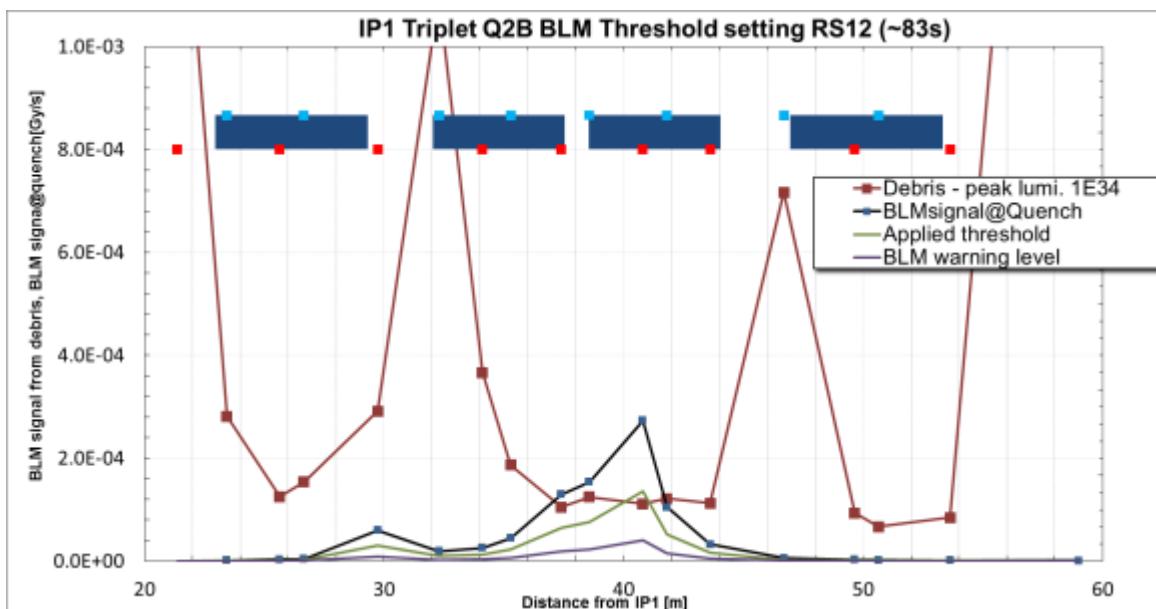
Q2B loss scenario – BLM signal at quench

- One should assure that BLMs are not in the warning level (30% of the threshold)
- Ratio between the Warning level/Debris(10^{34}) should be greater than 1

Applied Threshold = $0.5 \cdot \text{BLMSignal@Quench}$

Warning level = $0.3 \cdot \text{Applied Threshold}$

$$\frac{\text{Warning level}}{\text{Debris}(10^{34})} > 1$$



Q2B Loss Scenario – Threshold Corrections

- Correction for the debris – threshold from the last RS with ratio >1 stays for the next RS
- BLMs which don't see enough signal from the Q2B loss need different loss scenario

BLM Name	DCUM	Ratio Warning level/Debris(10^{34}) @ 6.5 TeV IP 1&5											
		RS1 0.00004	RS2 0.00008	RS3 0.00032	RS4 0.00064	RS5 0.00256	RS6 0.01024	RS7 0.08192	RS8 0.65536	RS9 1.31072	RS10 5.24288	RS11 20.97152	RS12 83.88608
BLMQI.01R1.B2I30_MQXA	21.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BLMQI.01R1.B1E10_MQXA	23.44	6.20	5.87	3.17	1.83	0.67	0.28	0.05	0.01	0.00	0.00	0.00	0.00
BLMQI.01R1.B2I20_MQXA	25.65	29.41	27.85	15.06	8.67	3.17	1.31	0.23	0.03	0.02	0.01	0.00	0.00
BLMQI.01R1.B1E20_MQXA	26.65	28.88	27.36	14.80	8.52	3.12	1.29	0.22	0.03	0.02	0.01	0.00	0.00
BLMQI.02R1.B2I30_MQXB	29.75	225.86	213.92	115.70	66.62	24.37	10.07	1.73	0.22	0.13	0.05	0.03	0.03
BLMQI.01R1.B1E30_MQXA	32.30	18.95	17.95	9.71	5.59	2.04	0.84	0.15	0.02	0.01	0.00	0.00	0.00
BLMQI.02R1.B2I23_MQXB	34.12	77.03	72.96	39.46	22.72	8.31	3.43	0.59	0.08	0.04	0.02	0.01	0.01
BLMQI.02R1.B1E21_MQXB	35.30	261.92	248.07	134.17	77.25	28.26	11.68	2.01	0.26	0.15	0.06	0.04	0.04
BLMQI.02R1.B2I22_MQXB	37.41	1359.33	1287.47	696.31	400.94	146.65	60.60	10.41	1.35	0.78	0.29	0.19	0.18
BLMQI.02R1.B1E22_MQXB	38.57	1356.02	1284.33	694.62	399.96	146.29	60.45	10.39	1.35	0.78	0.29	0.19	0.18
BLMQI.02R1.B2I21_MQXB	40.81	2701.96	2559.12	1384.07	796.95	291.50	120.45	20.70	2.69	1.55	0.58	0.38	0.37
BLMQI.02R1.B1E23_MQXB	41.81	947.81	897.70	485.51	279.56	102.25	42.25	7.26	0.94	0.54	0.20	0.13	0.13
BLMQI.03R1.B2I30_MQXA	43.62	318.65	301.80	163.23	93.99	34.38	14.20	2.44	0.32	0.18	0.07	0.04	0.04
BLMQI.02R1.B1E30_MQXB	46.69	8.90	8.43	4.56	2.62	0.96	0.40	0.07	0.01	0.01	0.00	0.00	0.00
BLMQI.03R1.B2I20_MQXA	49.65	29.40	27.84	15.06	8.67	3.17	1.31	0.23	0.03	0.02	0.01	0.00	0.00
BLMQI.03R1.B1E20_MQXA	50.65	33.44	31.67	17.13	9.86	3.61	1.49	0.26	0.03	0.02	0.01	0.00	0.00
BLMQI.03R1.B2I10_MQXA	53.63	17.61	16.68	9.02	5.19	1.90	0.79	0.13	0.02	0.01	0.00	0.00	0.00
BLMQI.03R1.B1E30_MQXA	59.01	0.22	0.21	0.11	0.07	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00

BLM can protect in the given RS



IP1&5 IT –

BLM Threshold Corrections

- Loss scenario – MQXA – Orbit Bump, MQXB – Q2B loss
- Correction for the debris – threshold from the last RS with ratio >1 stays for the next RS

BLM Name	Distance from IP	Ratio Warning level/Debris(10^{34}) @ 6.5 TeV IP1&5											
		RS1	RS2	RS3	RS4	RS5	RS6	RS7	RS8	RS9	RS10	RS11	RS12
		0.00004	0.00008	0.00032	0.00064	0.00256	0.01024	0.08192	0.65536	1.31072	5.24288	20.97152	83.88608
BLMQI.01R1.B2I30_MQXA	21.374	385.50	363.09	147.17	84.23	30.62	12.56	2.21	0.36	0.23	0.09	0.05	0.04
BLMQI.01R1.B1E10_MQXA	23.44	2661.91	2507.55	1016.45	581.75	211.48	86.75	15.28	2.50	1.58	0.63	0.34	0.30
BLMQI.01R1.B2I20_MQXA	25.65	5975.08	5628.60	2281.57	1305.83	474.70	194.71	34.29	5.61	3.55	1.41	0.75	0.66
BLMQI.01R1.B1E20_MQXA	26.65	4879.74	4596.78	1863.32	1066.45	387.68	159.02	28.01	4.58	2.90	1.15	0.61	0.54
BLMQI.02R1.B2I30_MQXB	29.7492	56.47	53.48	28.92	16.65	6.09	2.52	0.87	0.22	0.13	0.05	0.03	0.03
BLMQI.01R1.B1E30_MQXA	32.2992	528.88	498.13	201.91	115.56	42.01	17.23	3.03	0.50	0.31	0.13	0.07	0.06
BLMQI.02R1.B2I23_MQXB	34.116	19.26	18.24	9.86	5.68	2.08	0.86	0.30	0.08	0.04	0.02	0.01	0.01
BLMQI.02R1.B1E21_MQXB	35.296	65.48	62.02	33.54	19.31	7.06	2.92	1.00	0.26	0.15	0.06	0.04	0.04
BLMQI.02R1.B2I22_MQXB	37.41	339.83	321.87	174.08	100.23	36.66	15.15	5.21	1.35	0.78	0.29	0.19	0.18
BLMQI.02R1.B1E22_MQXB	38.57	339.01	321.08	173.65	99.99	36.57	15.11	5.19	1.35	0.78	0.29	0.19	0.18
BLMQI.02R1.B2I21_MQXB	40.808	675.49	639.78	346.02	199.24	72.88	30.11	10.35	2.69	1.55	0.58	0.38	0.37
BLMQI.02R1.B1E23_MQXB	41.808	236.95	224.42	121.38	69.89	25.56	10.56	3.63	0.94	0.54	0.20	0.13	0.13
BLMQI.03R1.B2I30_MQXA	43.6212	5169.76	4869.20	1973.61	1129.55	410.61	168.42	29.66	4.85	3.07	1.22	0.65	0.57
BLMQI.02R1.B1E30_MQXB	46.692	2.22	2.11	1.14	0.66	0.24	0.10	0.03	0.01	0.01	0.00	0.00	0.00
BLMQI.03R1.B2I20_MQXA	49.65	8036.79	7570.76	3068.83	1756.41	638.49	261.90	46.12	7.54	4.78	1.90	1.01	0.89
BLMQI.03R1.B1E20_MQXA	50.65	11173.83	10525.89	4266.70	2441.99	887.72	364.13	64.13	10.48	6.64	2.64	1.41	1.24
BLMQI.03R1.B2I10_MQXA	53.632	8826.35	8314.53	3370.32	1928.96	701.22	287.63	50.66	8.28	5.24	2.09	1.11	0.98
BLMQI.03R1.B1E30_MQXA	59.012	198.28	186.75	75.70	43.32	15.75	6.46	1.14	0.19	0.12	0.05	0.02	0.02

BLM is not in the warning level

Q2B loss scenario

Dynamic Orbit Bump loss scenario



IP1&5 IT – BLM Family Proposal

- Families for IP1&IP5 L&R
- Combine B1&B2 as proposed on all cold magnets – debris correction for the most limiting monitor

		Ratio Warning level/Debris(10^{34}) @ 6.5 TeV IP1&5											
BLM Name	Family	RS1 0.00004	RS2 0.00008	RS3 0.00032	RS4 0.00064	RS5 0.00256	RS6 0.01024	RS7 0.08192	RS8 0.65536	RS9 1.31072	RS10 5.24288	RS11 20.97152	RS12 83.88608
BLMQI.01R1.B2I30_MQXA	MQXA 30	385.50	363.09	147.17	84.23	30.62	12.56	2.21	0.36	0.23	0.09	0.05	0.04
BLMQI.01R1.B1E10_MQXA	MQXA 10	2661.91	2507.55	1016.45	581.75	211.48	86.75	15.28	2.50	1.58	0.63	0.34	0.30
BLMQI.01R1.B2I20_MQXA	MQXA 20	5975.08	5628.60	2281.57	1305.83	474.70	194.71	34.29	5.61	3.55	1.41	0.75	0.66
BLMQI.01R1.B1E20_MQXA	MQXA 20	4879.74	4596.78	1863.32	1066.45	387.68	159.02	28.01	4.58	2.90	1.15	0.61	0.54
BLMQI.02R1.B2I30_MQXB	MQXB 30	56.47	53.48	28.92	16.65	6.09	2.52	0.87	0.22	0.13	0.05	0.03	0.03
BLMQI.01R1.B1E30_MQXA	MQXA 30	528.88	498.13	201.91	115.56	42.01	17.23	3.03	0.50	0.31	0.13	0.07	0.06
BLMQI.02R1.B2I23_MQXB	MQXB 23	19.26	18.24	9.86	5.68	2.08	0.86	0.30	0.08	0.04	0.02	0.01	0.01
BLMQI.02R1.B1E21_MQXB	MQXB 21	65.48	62.02	33.54	19.31	7.06	2.92	1.00	0.26	0.15	0.06	0.04	0.04
BLMQI.02R1.B2I22_MQXB	MQXB 22	339.83	321.87	174.08	100.23	36.66	15.15	5.21	1.35	0.78	0.29	0.19	0.18
BLMQI.02R1.B1E22_MQXB	MQXB 22	339.01	321.08	173.65	99.99	36.57	15.11	5.19	1.35	0.78	0.29	0.19	0.18
BLMQI.02R1.B2I21_MQXB	MQXB B2 21	675.49	639.78	346.02	199.24	72.88	30.11	10.35	2.69	1.55	0.58	0.38	0.37
BLMQI.02R1.B1E23_MQXB	MQXB 23	236.95	224.42	121.38	69.89	25.56	10.56	3.63	0.94	0.54	0.20	0.13	0.13
BLMQI.03R1.B2I30_MQXA	MQXA 30	5169.76	4869.20	1973.61	1129.55	410.61	168.42	29.66	4.85	3.07	1.22	0.65	0.57
BLMQI.02R1.B1E30_MQXB	MQXB 30	2.22	2.11	1.14	0.66	0.24	0.10	0.03	0.01	0.01	0.00	0.00	0.00
BLMQI.03R1.B2I20_MQXA	MQXA 20	8036.79	7570.76	3068.83	1756.41	638.49	261.90	46.12	7.54	4.78	1.90	1.01	0.89
BLMQI.03R1.B1E20_MQXA	MQXA B1 20	11173.83	10525.89	4266.70	2441.99	887.72	364.13	64.13	10.48	6.64	2.64	1.41	1.24
BLMQI.03R1.B2I10_MQXA	MQXA 10	8826.35	8314.53	3370.32	1928.96	701.22	287.63	50.66	8.28	5.24	2.09	1.11	0.98
BLMQI.03R1.B1E30_MQXA	MQXA 30	198.28	186.75	75.70	43.32	15.75	6.46	1.14	0.19	0.12	0.05	0.02	0.02

BLM is not in the warning level

Q2B loss scenario

Dynamic Orbit Bump loss scenario

Lost sensitivity – merging B1 and B2



IP2&8 IT –

BLM Threshold Corrections

- Debris data taken from the IP8 BLM measured data and extrapolated to the 6.5 TeV and P8 foreseen luminosity for Run2 : 4e32 cm⁻²s⁻¹ (Richard Jacobsson – session 4 at RLIUP)

BLM Name	Distance from IP	Ratio Warning level/Debris(10^{34}) @ 6.5 TeV IP2&8											
		RS1 0.00004	RS2 0.00008	RS3 0.00032	RS4 0.00064	RS5 0.00256	RS6 0.01024	RS7 0.08192	RS8 0.65536	RS9 1.31072	RS10 5.24288	RS11 20.97152	RS12 83.88608
BLMQI.01R8.B2E30_MQXA	21.374	603.15	568.08	230.26	131.78	47.91	19.65	3.46	0.57	0.36	0.14	0.08	0.07
BLMQI.01R8.B1I10_MQXA	23.44	2240.50	2110.58	855.53	489.65	178.00	73.01	12.86	2.10	1.33	0.53	0.28	0.25
BLMQI.01R8.B2E20_MQXA	25.65	27048.01	25479.56	10328.23	5911.22	2148.87	881.43	155.23	25.38	16.07	6.40	3.40	3.00
BLMQI.01R8.B1I20_MQXA	26.65	529020.25	498343.59	202005.27	115614.99	42028.76	17239.52	3036.16	496.40	314.35	125.17	66.59	58.71
BLMQI.02R8.B2E30_MQXB	29.7492	1541.21	1459.73	789.48	454.58	166.27	68.70	23.61	6.13	3.54	1.32	0.86	0.84
BLMQI.01R8.B1I30_MQXA	32.2992	25059.36	23602.45	9566.67	5475.28	1990.36	816.40	143.78	23.51	14.89	5.93	3.16	2.78
BLMQI.02R8.B2E23_MQXB	34.116	923.32	874.51	472.97	272.34	99.61	41.16	14.15	3.67	2.12	0.79	0.51	0.50
BLMQI.02R8.B1I21_MQXB	35.296	3955.80	3746.66	2026.34	1166.77	426.77	176.34	60.60	15.74	9.08	3.39	2.20	2.15
BLMQI.02R8.B2E22_MQXB	37.41	18441.13	17466.20	9446.40	5439.25	1989.52	822.06	282.51	73.39	42.33	15.79	10.27	10.02
BLMQI.02R8.B1I22_MQXB	38.57	23317.68	22084.94	11944.39	6877.60	2515.62	1039.44	357.22	92.80	53.53	19.97	12.98	12.67
BLMQI.02R8.B2E21_MQXB	40.808	43915.77	41594.06	22495.68	12953.05	4737.84	1957.65	672.78	174.78	100.81	37.61	24.45	23.87
BLMQI.02R8.B1I23_MQXB	41.808	16418.80	15550.78	8410.47	4842.76	1771.34	731.91	251.53	65.34	37.69	14.06	9.14	8.92
BLMQI.03R8.B2E30_MQXA	43.6212	273170.17	257288.48	104285.52	59685.57	21696.71	8899.46	1567.33	256.27	162.29	64.64	34.40	30.33
BLMQI.02R8.B1I30_MQXB	46.692	141.29	133.82	72.38	41.67	15.24	6.30	2.16	0.56	0.32	0.12	0.08	0.08
BLMQI.03R8.B2E20_MQXA	49.65	652573.39	614732.16	249183.77	142616.96	51844.62	21265.83	3745.26	612.34	387.77	154.40	82.14	72.42
BLMQI.03R8.B1I20_MQXA	50.65	903089.24	850721.17	344842.72	197366.07	71747.21	29429.55	5183.02	847.41	536.63	213.68	113.68	100.23
BLMQI.03R8.B2E10_MQXA	53.632	348551.16	328339.48	133093.52	76174.28	27691.14	11358.46	2000.41	327.06	207.11	82.47	43.87	38.68
BLMQL.03R8.B1I30_MQXA	59.012	423.01	398.41	161.49	92.42	33.60	13.78	2.43	0.40	0.25	0.10	0.05	0.05

BLM can protect in the given RS

Q2B loss scenario

Dynamic orbit Bump loss scenario



IP2&8 IT – BLM Family Proposal

- Debris data taken from the IP8 BLM measured data and extrapolated to the 6.5 TeV and P8 foreseen luminosity for Run2 : 4e32 cm-2s-1 (Richard Jacobsson – session 4 at RLIUP)

BLM Name	Family	Ratio Warning level/Debris(10^{34}) @ 6.5 TeV IP2&8											
		RS1 0.00004	RS2 0.00008	RS3 0.00032	RS4 0.00064	RS5 0.00256	RS6 0.01024	RS7 0.08192	RS8 0.65536	RS9 1.31072	RS10 5.24288	RS11 20.97152	RS12 83.88608
BLMQI.01R8.B2E30_MQXA	MQXA 30	602.46	567.43	229.99	131.63	47.85	19.63	3.46	0.57	0.36	0.14	0.08	0.07
BLMQI.01R8.B1I10_MQXA	MQXA 10	2235.71	2106.07	853.70	488.60	177.62	72.86	12.83	2.10	1.33	0.53	0.28	0.25
BLMQI.01R8.B2E20_MQXA	MQXA 20	26445.70	24912.17	10098.23	5779.59	2101.02	861.80	151.78	24.82	15.71	6.26	3.33	2.93
BLMQI.01R8.B1I20_MQXA	MQXA 20	57321.15	53997.23	21887.96	12527.28	4553.96	1867.96	328.98	53.79	34.06	13.56	7.22	6.36
BLMQI.02R8.B2E30_MQXB	MQXB 30	1459.69	1382.52	747.72	430.54	157.48	65.07	22.36	5.81	3.35	1.25	0.81	0.79
BLMQI.01R8.B1I30_MQXA	MQXA 30	24368.59	22951.84	9302.96	5324.35	1935.49	793.89	139.82	22.86	14.48	5.77	3.07	2.71
BLMQI.02R8.B2E23_MQXB	MQXB 23	850.43	805.47	435.63	250.84	91.75	37.91	13.03	3.38	1.95	0.73	0.47	0.46
BLMQI.02R8.B1I21_MQXB	MQXB 21	3076.37	2913.73	1575.86	907.38	331.89	137.14	47.13	12.24	7.06	2.63	1.71	1.67
BLMQI.02R8.B2E22_MQXB	MQXB 22	14390.30	13629.52	7371.37	4244.45	1552.49	641.48	220.46	57.27	33.03	12.32	8.01	7.82
BLMQI.02R8.B1I22_MQXB	MQXB 22	17938.59	16990.23	9188.98	5291.03	1935.30	799.65	274.82	71.39	41.18	15.36	9.99	9.75
BLMQI.02R8.B2E21_MQXB	MQXB 21	32340.47	30630.71	16566.28	9538.89	3489.04	1441.65	495.45	128.71	74.24	27.69	18.00	17.58
BLMQI.02R8.B1I23_MQXB	MQXB 23	12100.83	11461.09	6198.60	3569.17	1305.49	539.42	185.38	48.16	27.78	10.36	6.74	6.58
BLMQI.03R8.B2E30_MQXA	MQXA 30	212922.27	200543.30	81285.27	46521.87	16911.49	6936.68	1221.65	199.75	126.50	50.38	26.81	23.64
BLMQI.02R8.B1I30_MQXB	MQXB 30	135.43	128.27	69.37	39.95	14.61	6.04	2.07	0.54	0.31	0.12	0.08	0.07
BLMQI.03R8.B2E20_MQXA	MQXA 20	469044.85	441846.02	179103.79	102507.63	37263.93	15285.06	2691.95	440.13	278.71	110.98	59.04	52.06
BLMQI.03R8.B1I20_MQXA	MQXA 20	486095.04	457907.51	185614.36	106233.87	38618.51	15840.69	2789.80	456.13	288.84	115.01	61.19	53.95
BLMQI.03R8.B2E10_MQXA	MQXA 10	286866.11	270231.40	109539.22	62693.29	22790.48	9348.29	1646.39	269.18	170.46	67.87	36.11	31.84
BLMQI.03R8.B1I30_MQXA	MQXA 30	423.01	398.41	161.49	92.42	33.60	13.78	2.43	0.40	0.25	0.10	0.05	0.05

BLM can protect in the given RS

Q2B loss scenario

Dynamic orbit Bump loss scenario

Lost sensitivity – merging B1 and B2



Inner Triplet BLM Proposed Strategy – Family Changes

- Injection families are not part of this study!
 - Need further check if the old thresholds need corrections at 6.5 TeV
- Create IP1&5 and IP2&8 separate families by position, not distinguishing between B1 and B2 monitors
 - Thresholds receive debris correction from the BLM which sees the highest signal (either B1 or B2)
 - 7 Families IP2&8
 - 9 Families IP1&5 - 2 extra families dedicated for one monitor each
 - Family naming example:

THRI_B1B2.1_MQXA

THRI_B2.21_MQXB

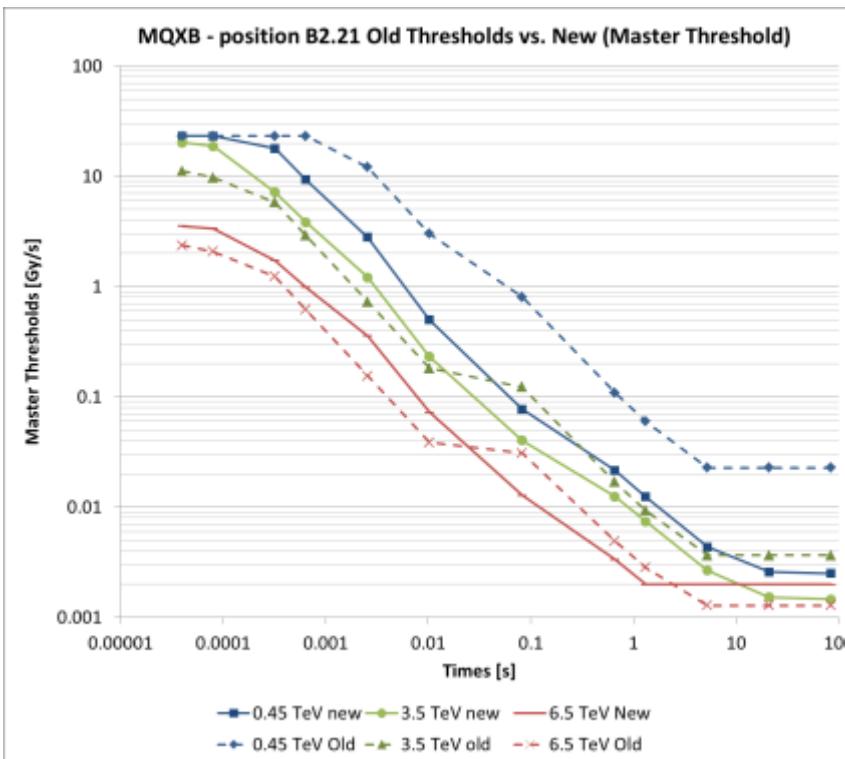


$$\text{MasterThreshold}(E, t) \cong N * \text{BLMSignal}@\text{Quench}(E, t) * \text{AdHoc}(E, t)$$

Comparison of the OLD and proposed thresholds – MQXB position 2 – THRI_B2.21_MQXB – IP1&5

Old thresholds:

- [Scale]Factor = 1.5
- Energy Deposit: Q2B loss (top energy) MQXB + Note 422 MB (Strong-kick event) * 4-wisdom factor at injection
- BLM Response: MQXB position 2 (CERN-ATS-Note-2012-014).
- Quench Level: Note 44 / D. Bocian parameters + steady state (CERN-ATS-Note-2012-014).



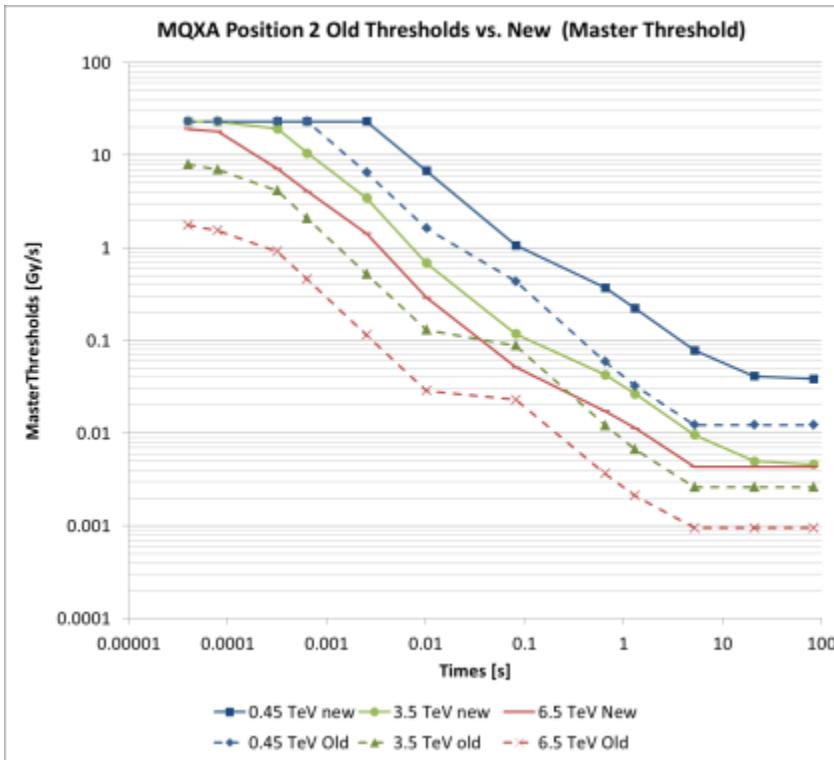
Used Adhoc factor
as proposed on all
1.9K magnets RS1-5: 4, RS6:2

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

Comparison of the OLD and proposed thresholds – MQXB position 2 – THRI_B1B2.2_MQXA – IP1&5

Old thresholds:

- Energy Deposit: Q2B loss (top energy) MQXB + Note 422 MB (Strong-kick event) * 4-wisdom factor at injection
- BLM Response: C. Kurfürst “TWISS” scenario
- Quench Level: Note 44 / D. Bocian parameters + steady state (CERN-ATS-Note-2012-014).



Used Adhoc factor
as proposed on all
1.9K magnets RS1-5: 4, RS6:2

Conclusions

- Luminosity debris cannot quench the triplet.
- Loss scenarios used for the threshold computation
 - MQXA – Dynamic Orbit Bump,
 - MQXB – Q2B loss scenario.
- Proposal of using monitor factor 0.166 i.e. factor 2 below predicted quench level.
- BLM signal from debris different between IP1&5 and IP2&8
 - Separate families proposed for IP1&5 and IP2&8
- Proposed to place B1 and B2 BLM in one family, grouping per position
 - Corrections applied according to the most limiting BLM
 - Corrections disable RS where the WarningLevel / Debris>1
- Most sensitive BLM placed in the dedicated family
 - P1&5 only.

Thank you for your attention!



Spares



All IP IT – Merged Family proposal

- Sensitivity lost in the IP8 BLMs with IP1 Thresholds

BLM Name	Distance from IP	Ratio Applied Threshold·0.3/Debris @ 6.5 TeV											
		RS1 0.00004	RS2 0.00008	RS3 0.00032	RS4 0.00064	RS5 0.00256	RS6 0.01024	RS7 0.08192	RS8 0.65536	RS9 1.31072	RS10 5.24288	RS11 20.97152	RS12 83.88608
BLMQI.01R8.B2E30_MQXA	21.374	603.15	568.08	230.26	131.78	47.91	19.65	3.46	0.57	0.36	0.14	0.08	0.07
BLMQI.01R8.B1I10_MQXA	23.44	2240.50	2110.58	855.53	489.65	178.00	73.01	12.86	2.10	1.33	0.53	0.28	0.25
BLMQI.01R8.B2E20_MQXA	25.65	27048.01	25479.56	10328.23	5911.22	2148.87	881.43	155.23	25.38	16.07	6.40	3.40	3.00
BLMQI.01R8.B1I20_MQXA	26.65	529020.25	498343.59	202005.27	115614.99	42028.76	17239.52	3036.16	496.40	314.35	125.17	66.59	58.71
BLMQI.02R8.B2E30_MQXB	29.7492	1541.21	1459.73	789.48	454.58	166.27	68.70	23.61	6.13	3.54	1.32	0.86	0.84
BLMQI.01R8.B1I30_MQXA	32.2992	25059.36	23602.45	9566.67	5475.28	1990.36	816.40	143.78	23.51	14.89	5.93	3.16	2.78
BLMQI.02R8.B2E23_MQXB	34.116	923.32	874.51	472.97	272.34	99.61	41.16	14.15	3.67	2.12	0.79	0.51	0.50
BLMQI.02R8.B1I21_MQXB	35.296	3955.80	3746.66	2026.34	1166.77	426.77	176.34	60.60	15.74	9.08	3.39	2.20	2.15
BLMQI.02R8.B2E22_MQXB	37.41	18441.13	17466.20	9446.40	5439.25	1989.52	822.06	282.51	73.39	42.33	15.79	10.27	10.02
BLMQI.02R8.B1I22_MQXB	38.57	23317.68	22084.94	11944.39	6877.60	2515.62	1039.44	357.22	92.80	53.53	19.97	12.98	12.67
BLMQI.02R8.B2E21_MQXB	40.808	43915.77	41594.06	22495.68	12953.05	4737.84	1957.65	672.78	174.78	100.81	37.61	24.45	23.87
BLMQI.02R8.B1I23_MQXB	41.808	16418.80	15550.78	8410.47	4842.76	1771.34	731.91	251.53	65.34	37.69	14.06	9.14	8.92
BLMQI.03R8.B2E30_MQXA	43.6212	273170.17	257288.48	104285.52	59685.57	21696.71	8899.46	1567.33	256.27	162.29	64.64	34.40	30.33
BLMQI.02R8.B1I30_MQXB	46.692	141.29	133.82	72.38	41.67	15.24	6.30	2.16	0.56	0.32	0.12	0.08	0.08
BLMQI.03R8.B2E20_MQXA	49.65	652573.39	614732.16	249183.77	142616.96	51844.62	21265.83	3745.26	612.34	387.77	154.40	82.14	72.42
BLMQI.03R8.B1I20_MQXA	50.65	903089.24	850721.17	344842.72	197366.07	71747.21	29429.55	5183.02	847.41	536.63	213.68	113.68	100.23
BLMQI.03R8.B2E10_MQXA	53.632	348551.16	328339.48	133093.52	76174.28	27691.14	11358.46	2000.41	327.06	207.11	82.47	43.87	38.68
BLMQI.03R8.B1I30_MQXA	59.012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

BLM can protect in the given RS

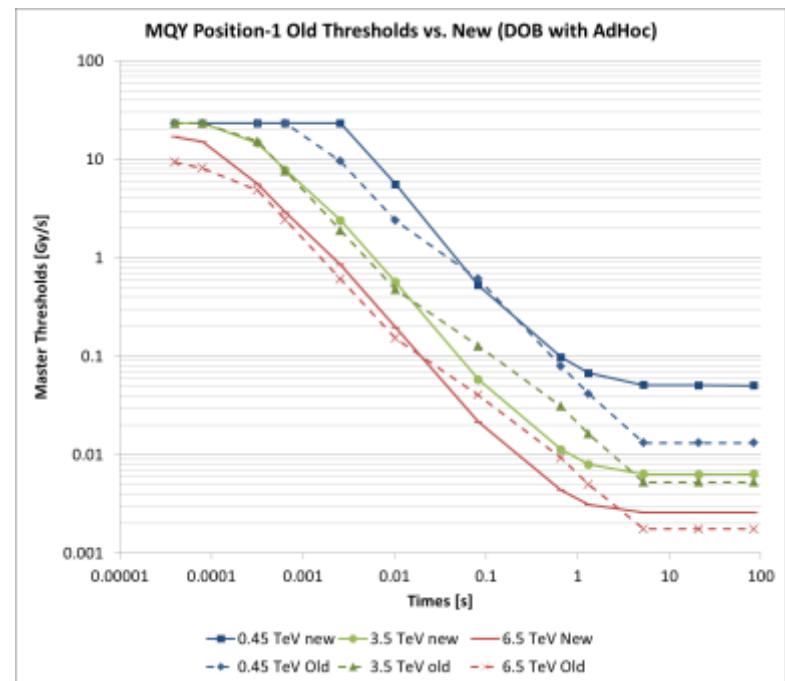
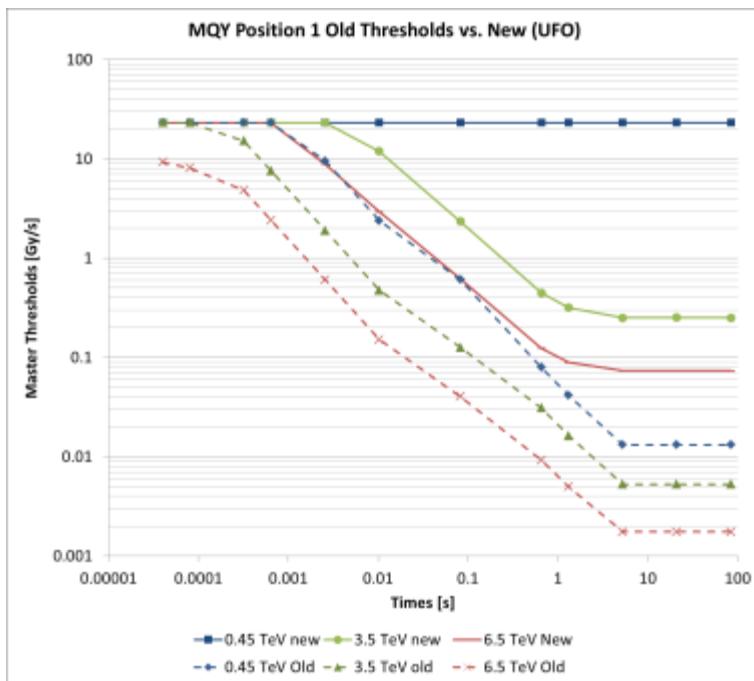
Q2B loss scenario

Dynamic orbit Bump loss scenario



MQY 4.5 K Position 1

UFO vs. DOB.



Paths (not) chosen: AdHoc corrections

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

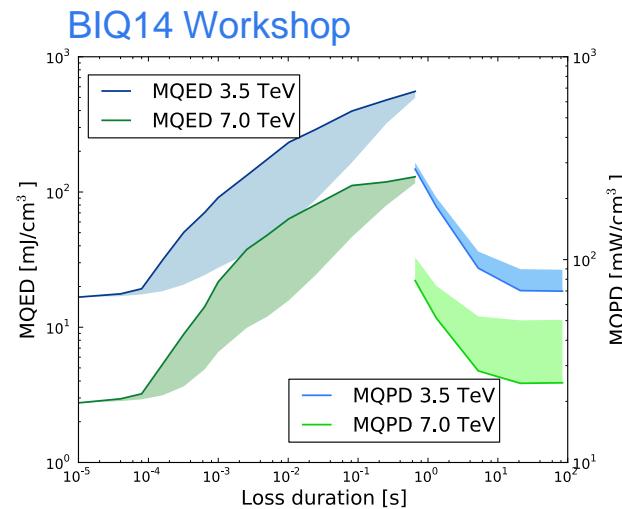
The electro-thermal model underestimated the quench level for the intermediate-loss orbit-bump quench test at 1.9 K (ADT).

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

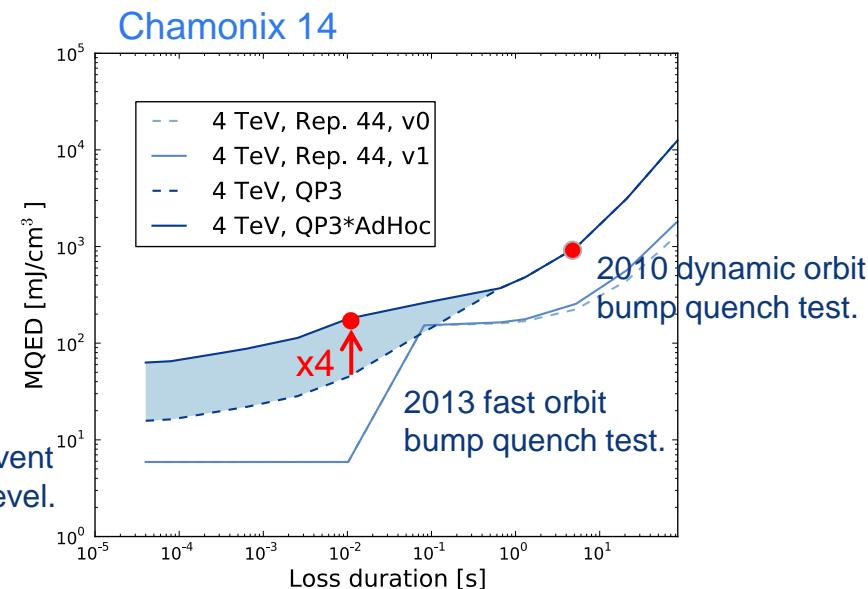
The only faster quench test produced single-turn losses.

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

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



2008 strong-kick event
validated quench level.



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

Paths (not) chosen: SS heat-transfer models

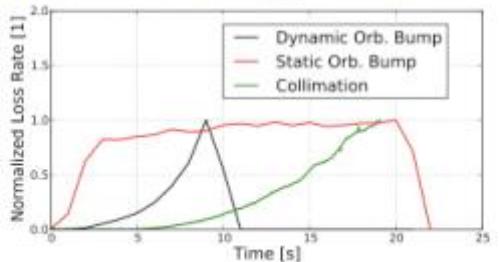
Based on steady-state orbit-bump quench test (ADT) analysis we select the more conservative empirical model for MB and MQ.

The model still gives much higher estimates than previously used.

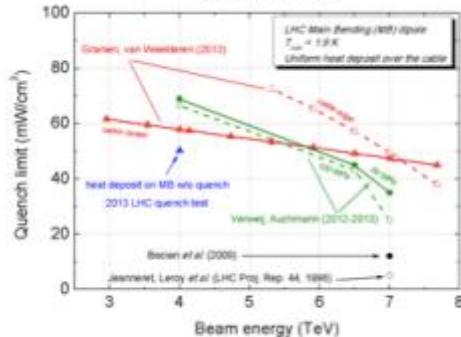
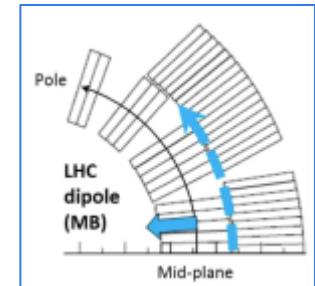
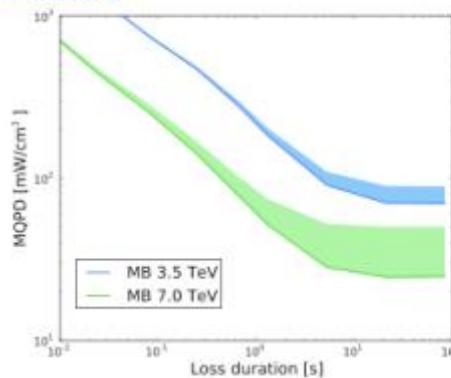
Steady-state losses (5 s – infinity)

- 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/cm ²]	FLUKA [mW/cm ²]
Dyn. Orbit Bump	3.5	MQ	6	180 ⁺³⁵	208
Collimation	4	MB	15	115 ⁺²⁵	n/a
Static Orbit Bump	4	MQ	infinity	70 ⁺¹⁸	41 ⁺³³



BIQ14 workshop



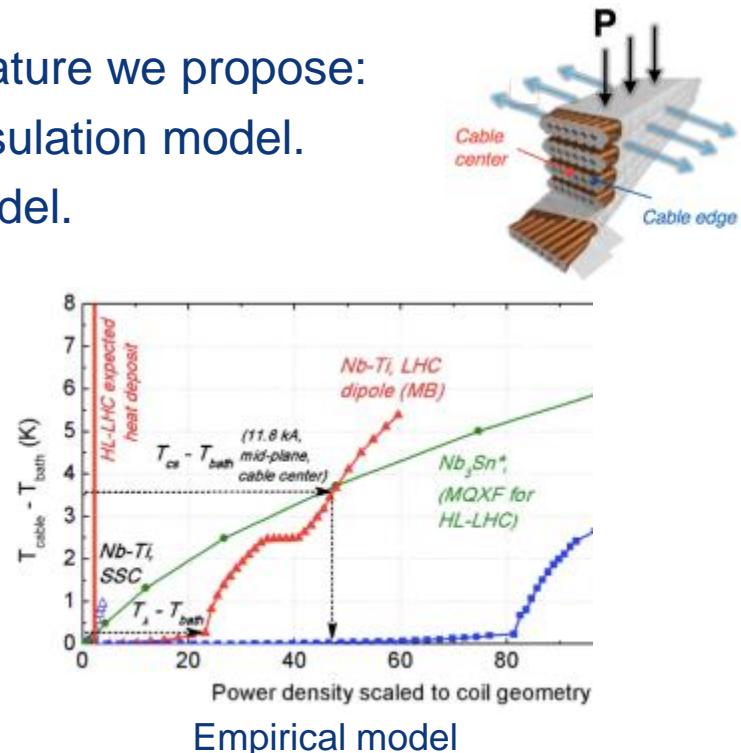
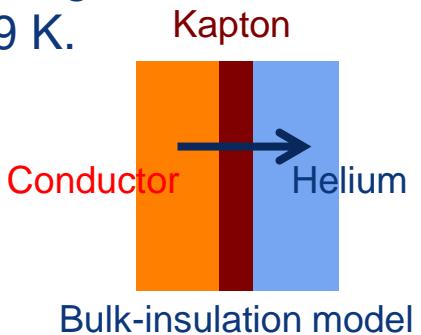
Courtesy P.P. Granier

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

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.



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.

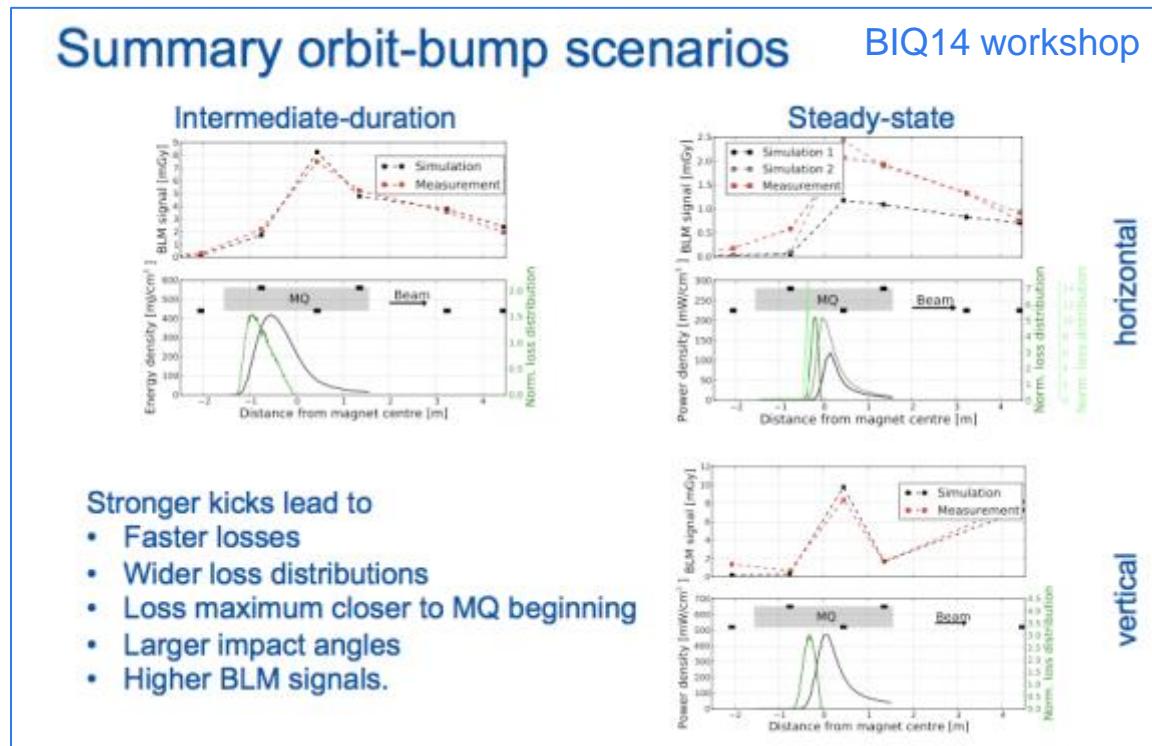
$$\text{BLMSignal}@\text{Quench}(E, t) = \frac{\text{BLMResponse}(E, t) * \text{QuenchLevel}(E, t)}{\text{EnergyDeposit}(E, t)}$$

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.



QP3 MQXB model

Quench level for the MQXB
with different cooling settings Istrand= 309A ~7TeV

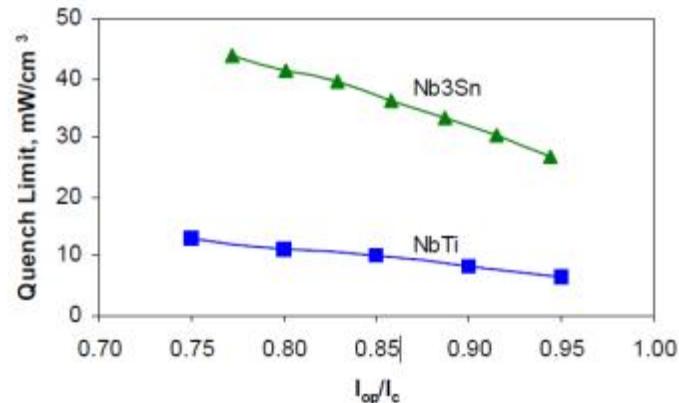
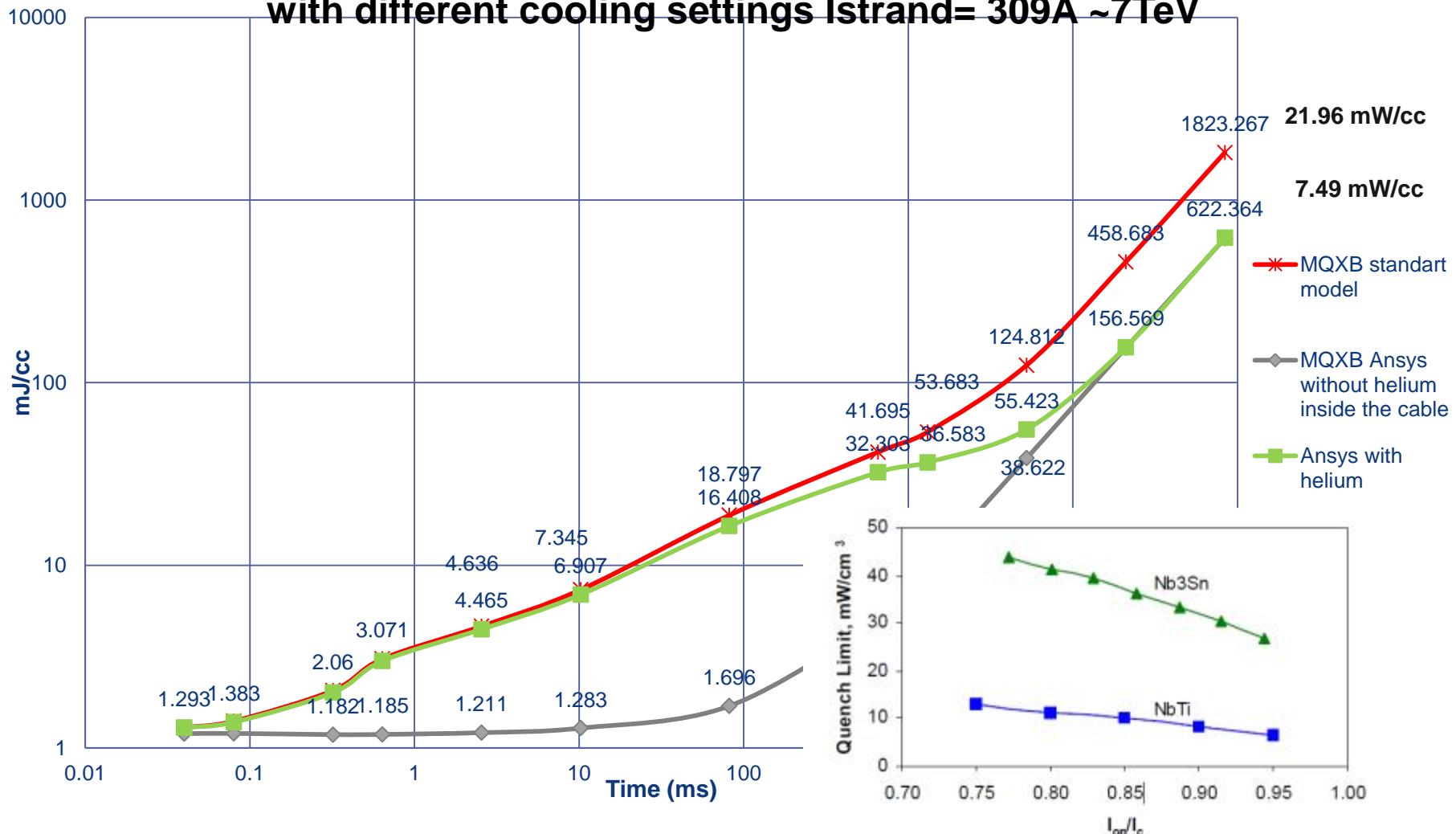


Fig. 7. Calculated quench limit at Top=1.9 K for Nb₃Sn and NbTi IRQ vs. the magnet operation current normalized on the magnet critical current.



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