Luminosity debris and Inner Triplet BLM

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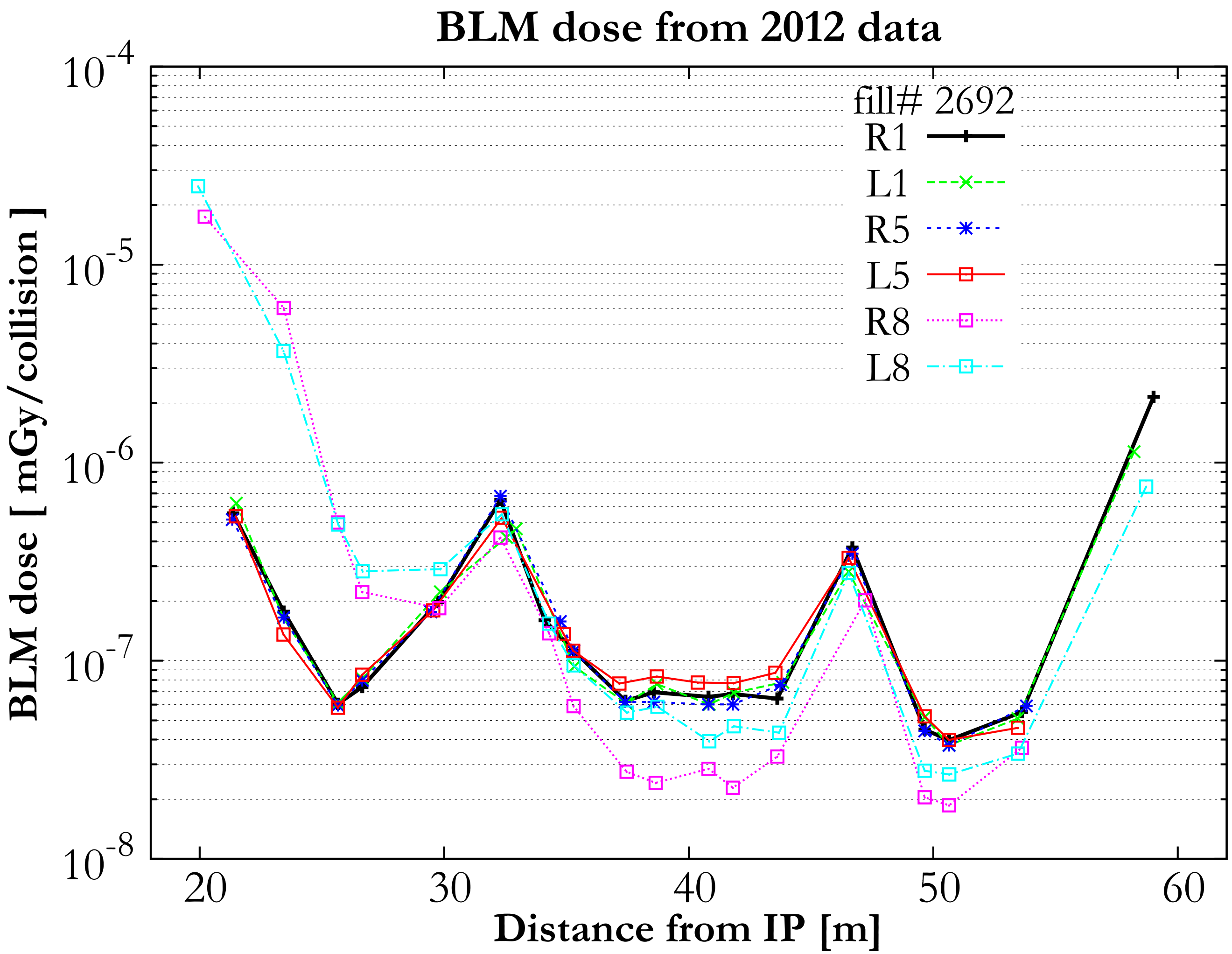
Outline

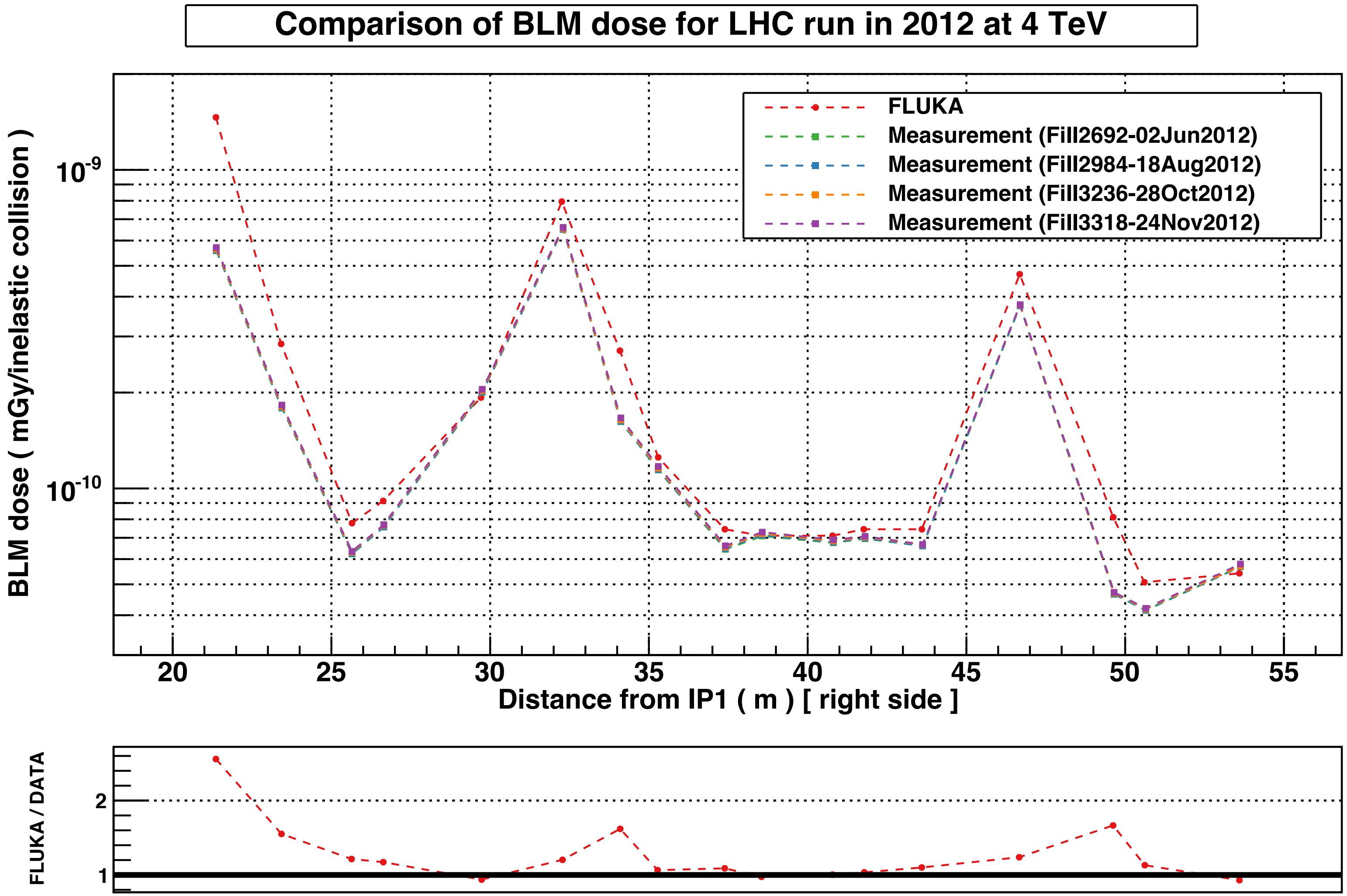
- 2012 BLM data and FLUKA benchmarks
- BLM response and peak power in the Inner Triplet quadrupoles for 6.5 TeV proton beam collisions
- Update of the quench limits for MQXA, MQXB
- Discussion on accidental scenarios
- Proposed strategy for setting IT BLM thresholds

2012 BLM data



- BLM signals alike for IR1/5 and left/right, whilst constant as function of fills
- Difference for P8 due to the absence of the TAS (and presence of spectrometer/compensators)

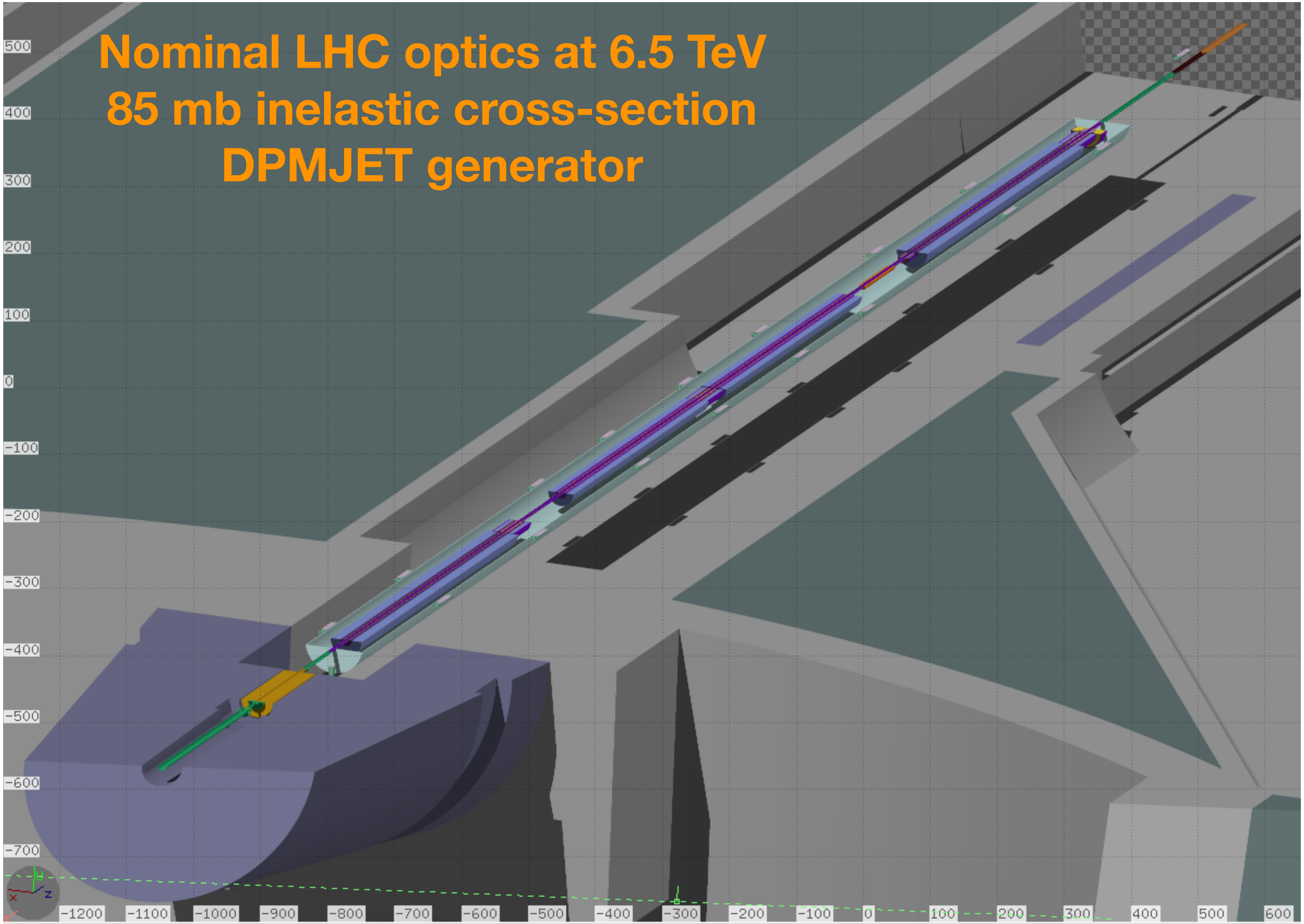
FLUKA benchmark with BLM data @4 TeV - P1



BLM pattern well reproduced

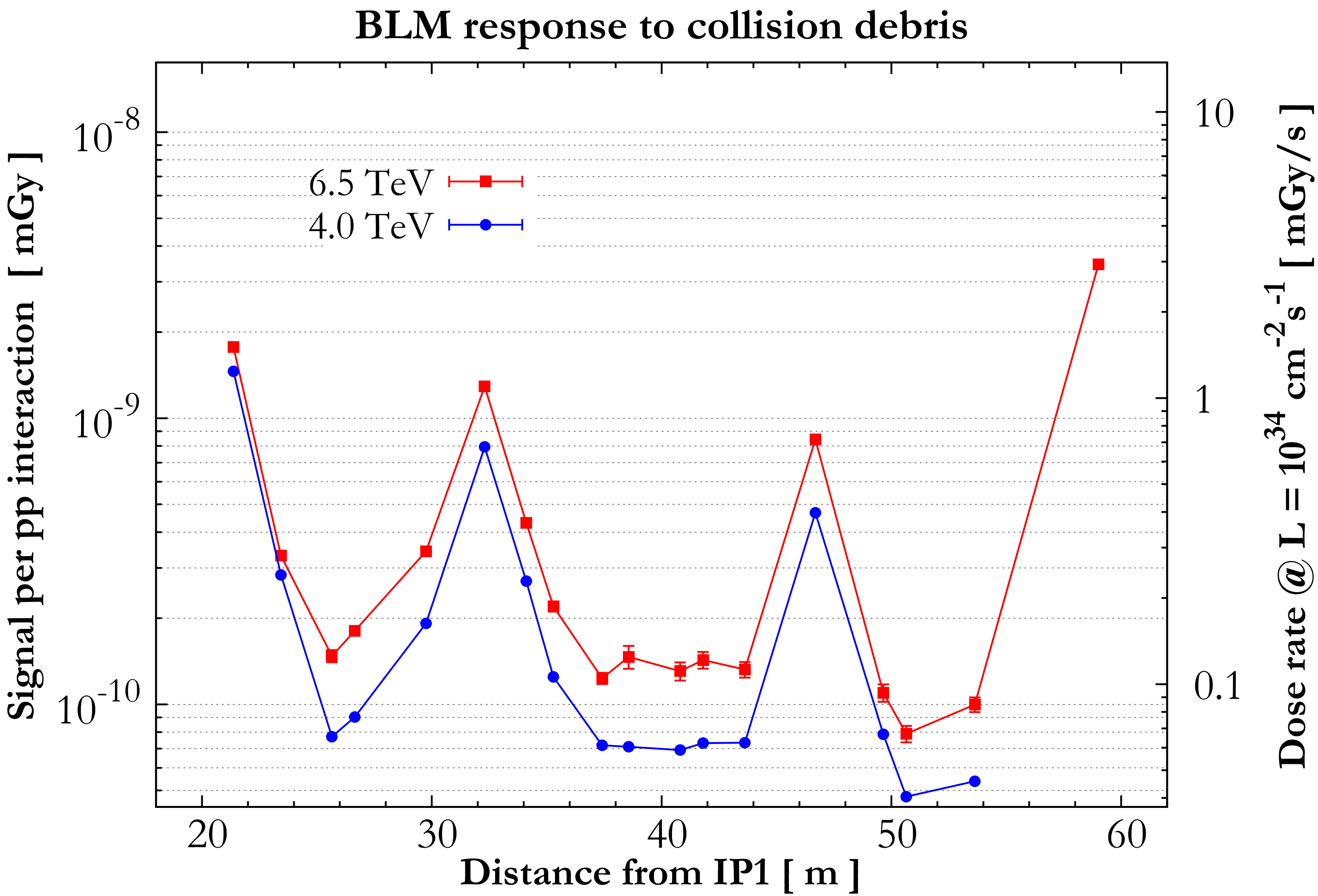
Deviations for the first BLM and the first BLMs after interconnects

IR1 simulation for 6.5 TeV protons



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

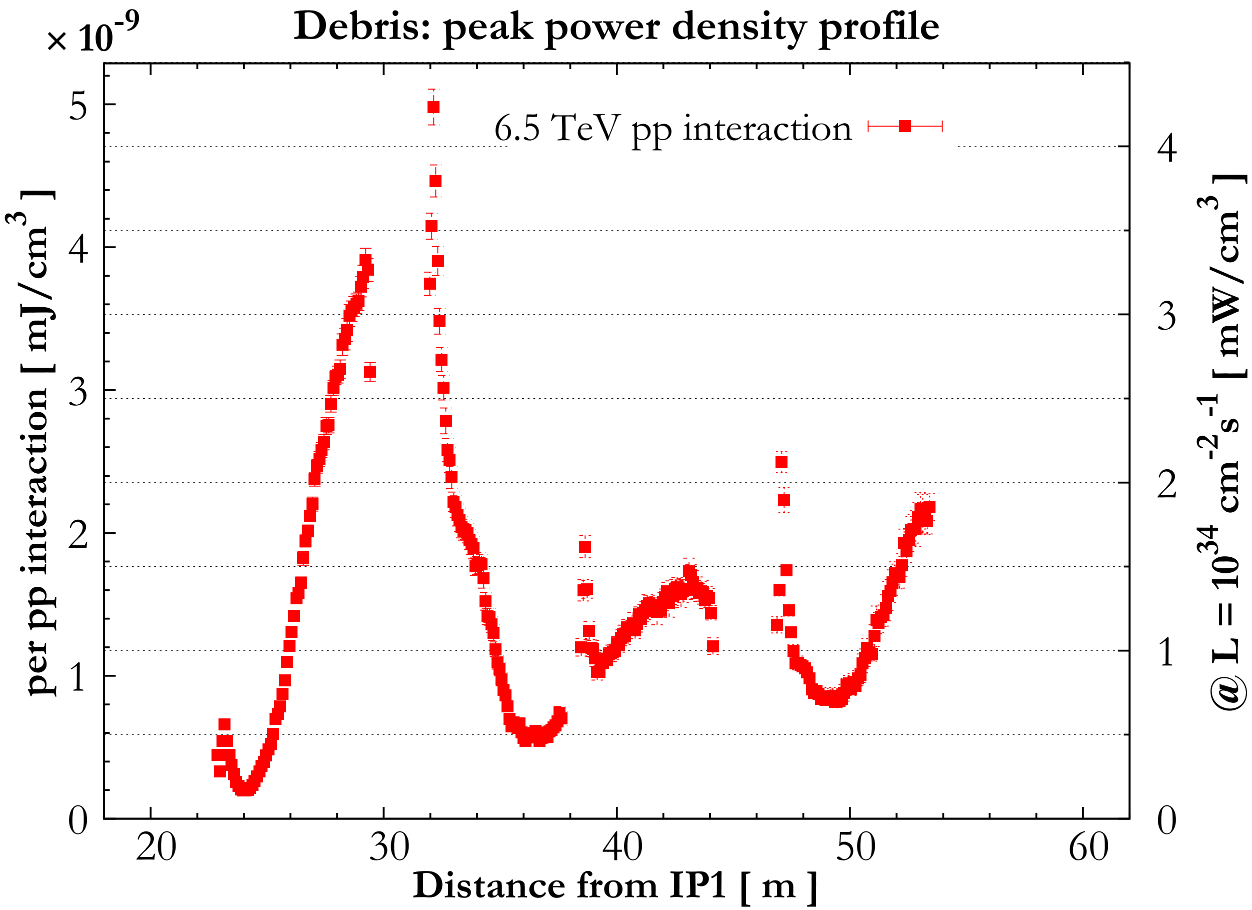
Signal in the BLMs

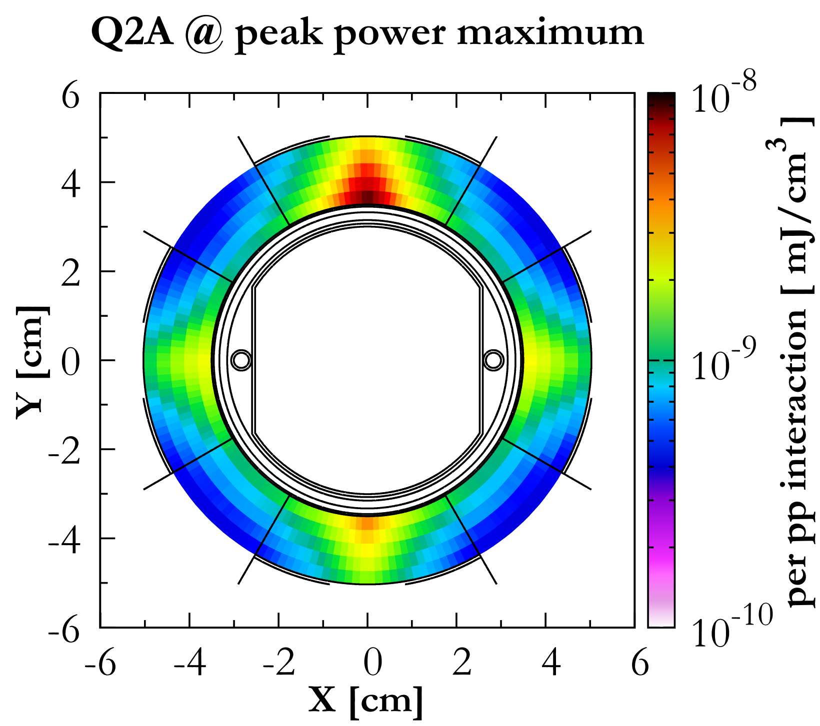


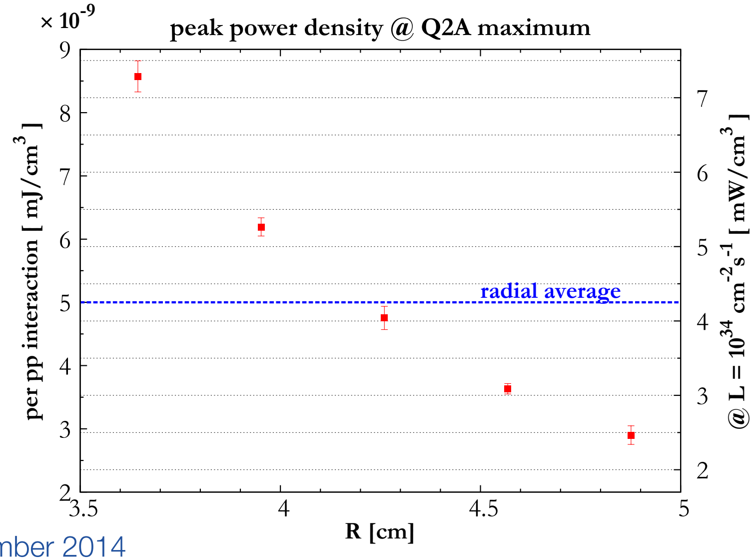
Consistent with previous (7 TeV) study reported in CERN-ATS-Note-2012-014 TECH

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

Energy deposition on the SC coils







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

MQX quench levels

Magnet	MQPD	Luminosity 1E+34 [$cm^{-2} \cdot s^{-1}$]		Luminosity 2E+34 [$cm^{-2} \cdot s^{-1}$]		Luminosity 5E+34 [$cm^{-2} \cdot s^{-1}$]	
		DPD	ratio DPD/MQPD	DPD	ratio DPD/MQPD	DPD	ratio DPD/MQPD
	[mW/cm3]	[mW/cm3]	-	[mW/cm3]	-	[mW/cm3]	-
MQXB	**19.743**	4.250	0.215	8.500	0.431	21.250	1.076
MQXA	**50.394**	3.400	0.067	6.800	0.135	17.000	0.337

Quench level is calculated for constant power in time
DPD is debris radial average power deposition in the magnet coil
MQPD comes from the QP3 electrothermal software, assuming constant power in time
Quench level is calculated for 6.5TeV since the Fluka debris data are 6.5TeV

Note that the Q2B scenario is calculated for the linear power rise in time, this produces ~ factor 2 lower quench limit than constant power

Quench power density higher than the values assumed so far,
(that were calculated assuming measurement results for MB)

- 18 mW/cm^3 for MQXA
- 13 mW/cm^3 for MQXB

[from R. Ostojic, 2005 Stability Workshop, 3-4 March 2005 and references therein]

Accidental scenarios

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

from CERN-ATS-Note-2012-014 TECH

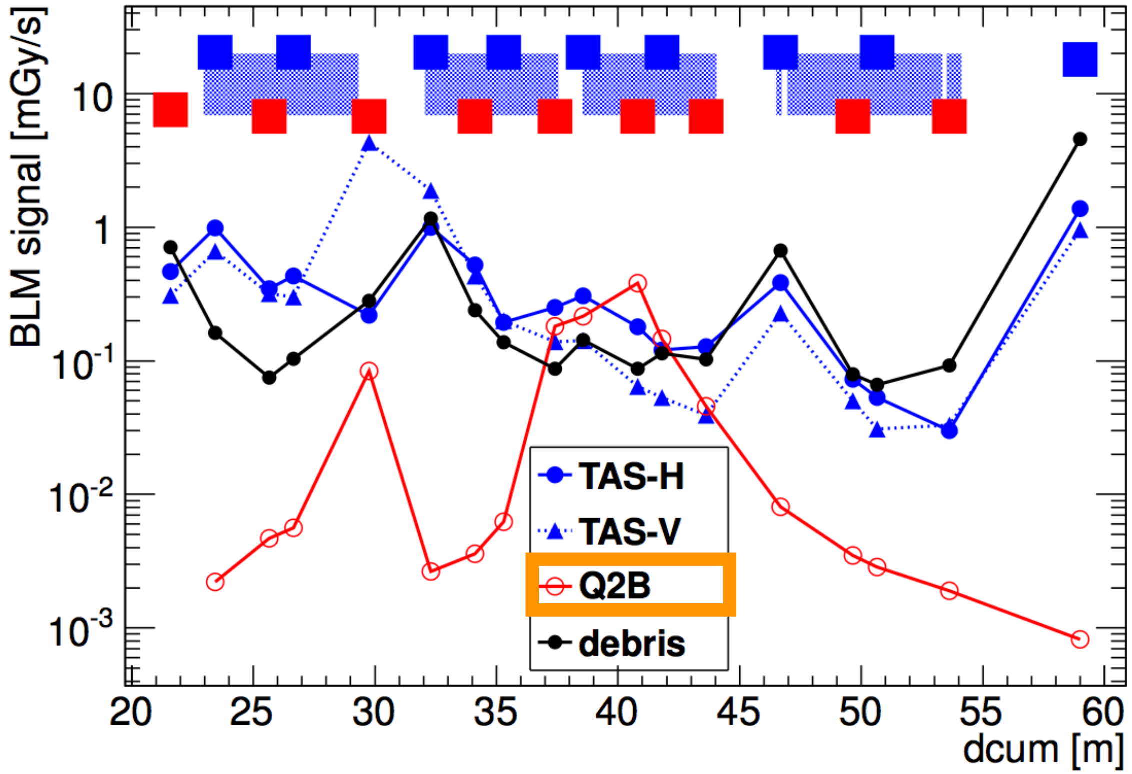
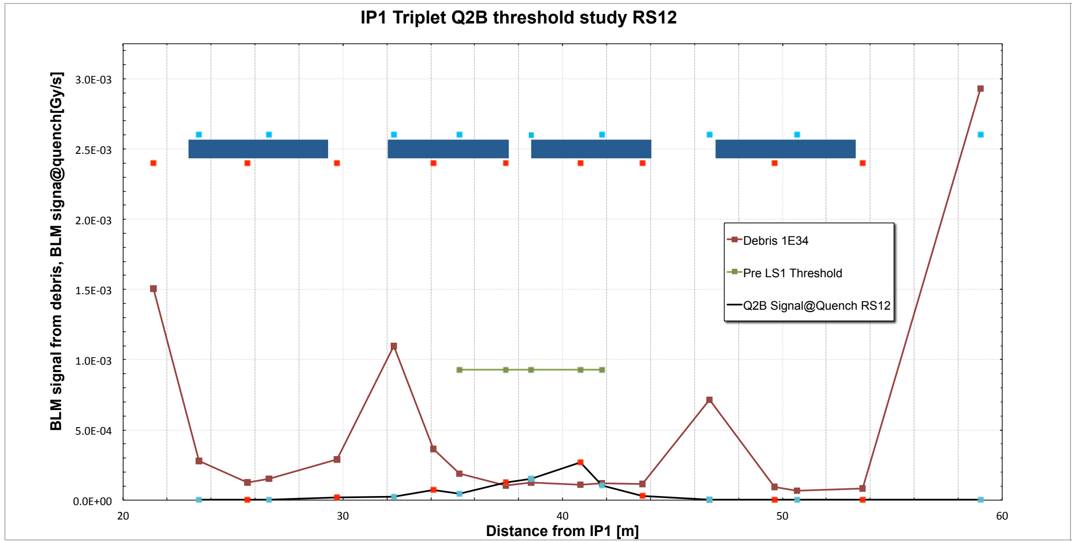


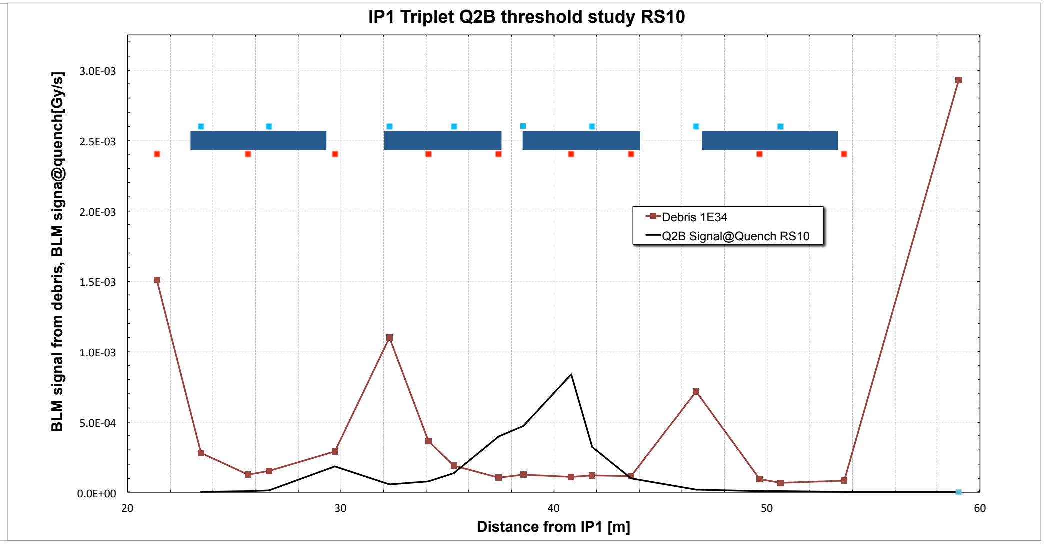
Figure 11: *BLM signals due to collision debris (black curve), and BLM signals at magnet quench for the three considered scenarios of proton steady state losses.*

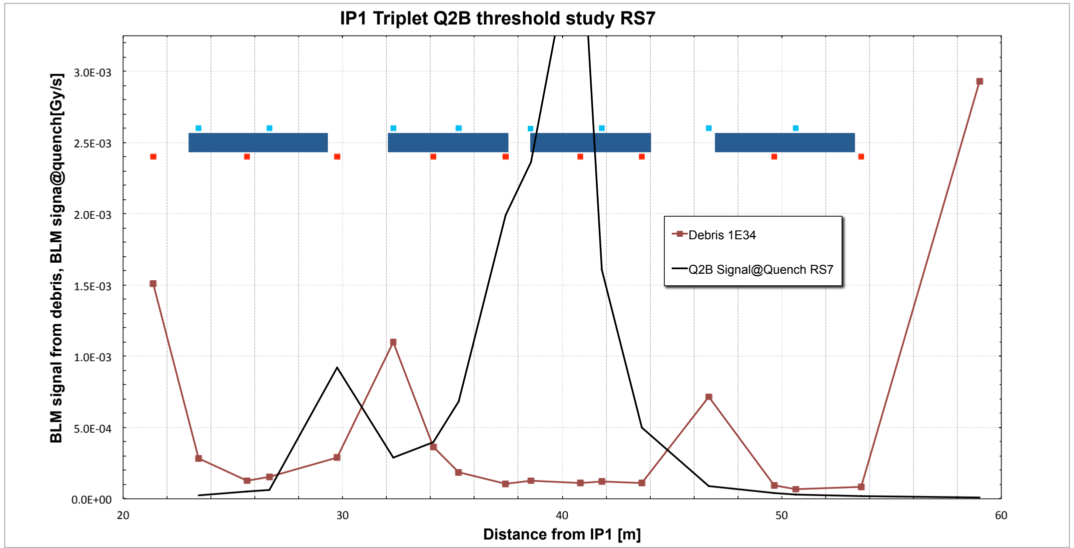
- The **Q2B case** as accidental beam loss scenario is based on the assumption of wrong collimators settings in IR7 or of retracted TCT
- re-analyses based on new tracking studies envisaged
- Low signal except few BLM around Q2B

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

BLM setting strategy (based on the Q2B scenario)



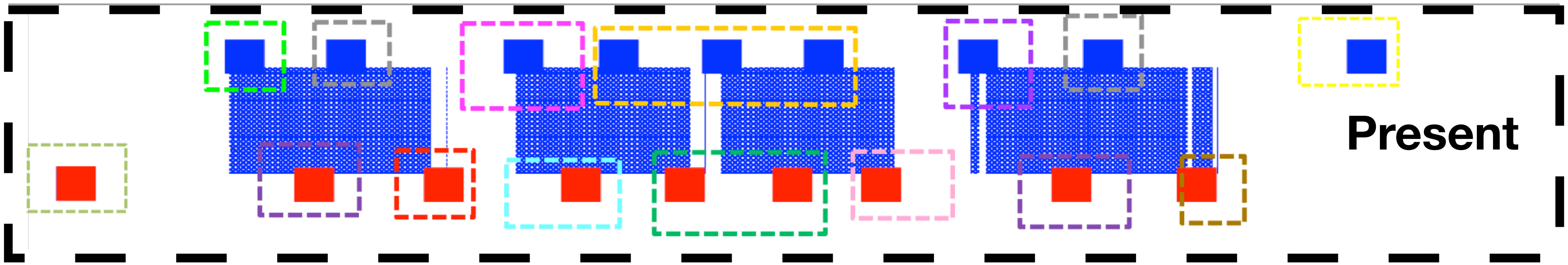




Rationale:

- Individuate BLMs with **ratio >= 3** with respect to luminosity debris that can prevent quenches due to Q2B losses
  ➔ However, no BLM can protect for Q2B in all running sums (RS)
- group BLMs into families defined by the maximum RS for which the ratio is >= 3
  - keep the BLM thresholds constant from there to RS12
- energy scaling of BLMResponse and EnergyDeposition neglected by keeping their ratio constant over all energies

Proposal for IT BLM families - PRELIMINARY



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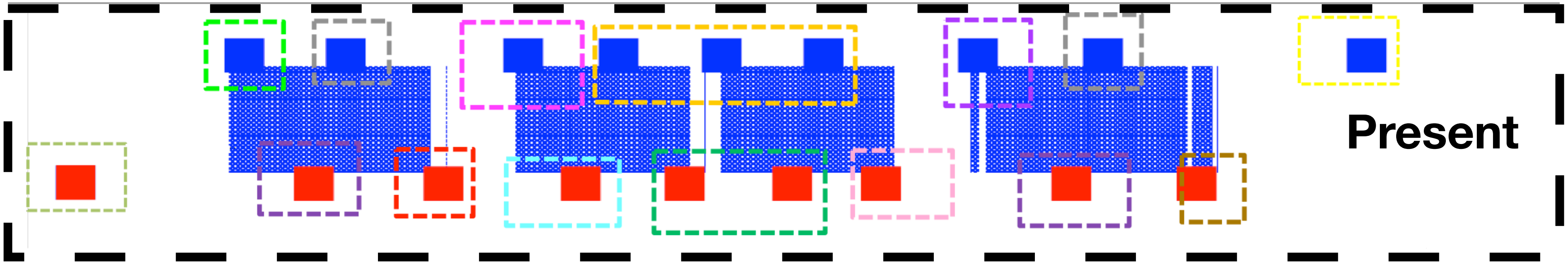

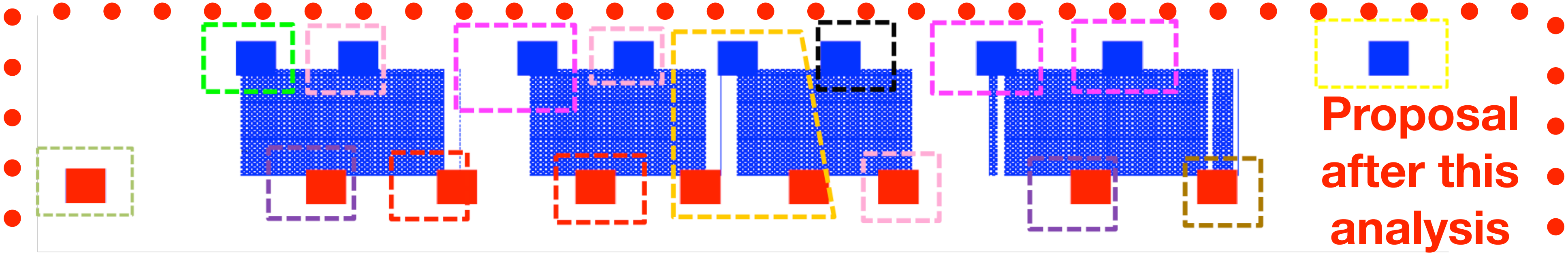

Ratio Signal @ Quench/Debris/3 3

	RS1	RS2	RS3	RS4	RS5	RS6	RS7	RS8	RS9	RS10	RS11	RS12
THRI_B2.3B_MQXA[6]	0	0	0	0	0	0	0	0	0	0	0	0
THRI_B1.1_MQXA[8]	2.425085	2.2140388	1.0306796	0.6909028	0.2639235	0.0983488	0.0288829	0.0089558	0.0057652	0.0027889	0.0020394	0.0018482
THRI_B2.2_MQXA[16]	11.50909	10.507496	4.891451	3.278921	1.2525412	0.4667489	0.137074	0.0425029	0.0273609	0.0132359	0.0096787	0.0087714
THRI_B1.2_MQXA[16]	167.66262	153.07157	71.257895	47.766809	18.246825	6.7995245	1.9968724	0.6191749	0.3985895	0.1928188	0.1409983	0.0086155
THRI_B2.3_MQXB[6]	27.992394	25.55632	11.896981	7.9749876	3.0464292	1.135226	0.3333912	0.1033754	0.0665472	0.0321924	0.0235406	0.0213337
THRI_3_MQXA_LumLoss[4]	10.043378	9.16934	4.2685123	2.8613421	1.0930269	0.4073072	0.1196173	0.03709	0.0238764	0.0115503	0.0084461	0.0076543
THRI_2_MQXB_LumLoss[2]	52.307327	47.755215	22.231014	14.902273	5.6926382	2.1213133	0.6229836	0.19317	0.1243518	0.0601555	0.0439886	0.064438
THRI_B1.2_MQXB[23]	102.50888	93.587915	43.567058	29.204614	11.156104	4.1572274	1.2208873	0.3785634	0.2436975	0.1178893	0.0862064	0.0781246
THRI_B2.2_MQXB[23]	532.00452	485.70614	226.10598	151.56722	57.898375	21.575338	6.3362074	1.9646828	1.2647506	0.6118266	0.447397	0.4054538
THRI_B1.2_MQXB[23]	530.70847	484.52288	225.55515	151.19798	57.757325	21.522777	6.3207714	1.9598965	1.2616694	0.6103361	0.4463071	0.4044661
THRI_B2.2_MQXB[23]	1057.4723	965.4444	449.4338	301.27214	115.08535	42.885579	12.594562	3.9052254	2.5139611	1.2161357	0.8892969	0.8059259
THRI_B1.2_MQXB[23]	370.94427	338.66237	157.65415	105.68142	40.37009	15.043571	4.4179696	1.3698903	0.8818571	0.4266009	0.311951	0.2827058
THRI_B2.3_MQXA[5]	124.71076	113.85764	53.003025	35.529893	13.572348	5.0576201	1.485313	0.4605545	0.2964787	0.1434224	0.1048773	0.0950452
THRI_3_MQXB_LumLoss[4]	3.4819698	3.1789469	1.4798638	0.9920075	0.3789449	0.1412106	0.0414705	0.0128588	0.0082778	0.0040044	0.0029282	0.0026537
THRI_B2.2_MQXA[16]	11.505644	10.504351	4.8899866	3.2779393	1.2521662	0.4666091	0.1370329	0.0424901	0.0273527	0.013232	0.0096758	0.0087687
THRI_B1.2_MQXA[16]	13.088202	11.949184	5.5625858	3.7288075	1.424397	0.5307894	0.1558813	0.0483345	0.031115	0.015052	0.0110067	0.0099748
THRI_B2.1_MQXA[8]	6.8923571	6.2925409	2.9293044	1.9636214	0.7500994	0.2795182	0.0820884	0.0254533	0.0163854	0.0079265	0.0057962	0.0052528
THRI_B1.3B_MQXA[6]	0.0864827	0.0789564	0.0367558	0.0246388	0.009412	0.0035073	0.00103	0.0003194	0.0002056	9.946E-05	7.273E-05	6.591E-05

Overview of the proposed strategy for IT BLMs

Monitor	Family	DCUM	old edep	old BLM	old QL	Ad hoc pre LS1	Proposal
BLMQI.01R1.B2I30_MQXA	THRI_B2.3B_MQXA[6]	21.374	set to maximum				se to maximum
BLMQI.01R1.B1E10_MQXA	THRI_B1.1_MQXA[8]	23.44	MQ_pattern_v2	IC_MQ_B1.1_v3	MQXA	Scale 1.2, UFO, DOB, RS10=RS11=RS12	ongoing
BLMQI.01R1.B2I20_MQXA	THRI_B2.2_MQXA[16]	25.65	MQXB_lossQ2B	IC_MQ_B1.2_v3	MQXA	UFO, DOB, RS10=RS11=RS12	ongoing
BLMQI.01R1.B1E20_MQXA	THRI_B1.2_MQXA[16]	26.65	MQXB_lossQ2B	IC_MQ_B1.2_v3	MQXA	UFO, DOB, RS10=RS11=RS12	Q2B RS7
BLMQI.02R1.B2I30_MQXB	THRI_B2.3_MQXB[6]	29.7492	MQXB_lossQ2B	IC_MQXB_B1.3_v1	MQXB	UFO, DOB, RS10=RS11=RS12	Q2B RS6
BLMQI.01R1.B1E30_MQXA	THRI_3_MQXA_LumLoss[4]	32.2992	MQXB_lossQ2B	IC_MQXB_B1.2_v2	MQXB	Scale 1.5, UFO, DOB, RS9=RS10=RS11=RS12	Q2B RS5
BLMQI.02R1.B2I23_MQXB	THRI_2_MQXB_LumLoss[2]	34.116	MQXB_lossQ2B	IC_MQXB_B1.2_v2	MQXB	Scale 1.5, UFO, DOB, RS9=RS10=RS11=RS12	ongoing
BLMQI.02R1.B1E21_MQXB	THRI_B1.2_MQXB[23]	35.296	MQXB_lossQ2B	IC_MQXB_B1.2_v2	MQXB	Scale 1.5, UFO, DOB, RS10=RS11=RS12	Q2B RS7
BLMQI.02R1.B2I22_MQXB	THRI_B2.2_MQXB[23]	37.41	MQXB_lossQ2B	IC_MQXB_B1.2_v2	MQXB	Scale 1.5, UFO, DOB, RS10=RS11=RS12	Q2B RS9
BLMQI.02R1.B1E22_MQXB	THRI_B1.2_MQXB[23]	38.57	MQXB_lossQ2B	IC_MQXB_B1.2_v2	MQXB	Scale 1.5, UFO, DOB, RS10=RS11=RS12	Q2B RS9
BLMQI.02R1.B2I21_MQXB	THRI_B2.2_MQXB[23]	40.808	MQXB_lossQ2B	IC_MQXB_B1.2_v3	MQXB	Scale 1.5, UFO, DOB, RS10=RS11=RS12	Q2B RS9
BLMQI.02R1.B1E23_MQXB	THRI_B1.2_MQXB[23]	41.808	MQXB_lossQ2B	IC_MQXB_B1.2_v4	MQXB	Scale 1.5, UFO, DOB, RS10=RS11=RS12	Q2B RS8
BLMQI.03R1.B2I30_MQXA	THRI_B2.3_MQXA[5]	43.6212	MQXB_lossQ2B	IC_MQXB_B1.2_v2	MQXB	Scale 1.5, UFO, DOB, RS10=RS11=RS12	Q2B RS7
BLMQI.02R1.B1E30_MQXB	THRI_3_MQXB_LumLoss[4]	46.692	MQXB_lossQ2B	IC_MQXB_B1.3_v1	MQXB	Scale 1.5, UFO, DOB, RS9=RS10=RS11=RS12	Q2B RS3
BLMQI.03R1.B2I20_MQXA	THRI_B2.2_MQXA[16]	49.65	MQXB_lossQ2B	IC_MQ_B1.2_v3	MQXA	UFO, DOB, RS10=RS11=RS12	ongoing
BLMQI.03R1.B1E20_MQXA	THRI_B1.2_MQXA[16]	50.65	MQXB_lossQ2B	IC_MQ_B1.2_v3	MQXA	UFO, DOB, RS10=RS11=RS12	Q2B RS5
BLMQI.03R1.B2I10_MQXA	THRI_B2.1_MQXA[8]	53.632	MQ_pattern_v2	IC_MQ_B1.1_v3	MQXA	UFO, DOB, RS10=RS11=RS12	ongoing
BLMQI.03R1.B1E30_MQXA	THRI_B1.3B_MQXA[6]	59.012	set to maximum				se to maximum

- Besides the Q2:
  - Q3 thresholds will be set in the same way as IPQ thresholds, i.e., with a combination of UFO losses (>4 TeV) and orbit-bump scenario, and for MQXA quench levels.
  - Q1 thresholds will be a copy-paste of Q3. This is conservative since Q1 is equipped with a thicker liner, but a reasonable starting point in the absence of dedicated models.

Summary

- The results discussed here represent an updated of CERN-ATS-Note-2012-014 TECH
- Also in view of the updated quench limits, luminosity debris should not limit operation
- An update of the BLM families and thresholds for IT will be proposed
- Other studies in the to-do list not discussed here:
  - BLM attached to TCL collimators (accurate BML position still to be specified)
  - Matching Section BLMs during forward physics operation