HiLumi
HL-LHC PROJECT

Energy deposition studies in IR7 for HL-LHC

C. Bahamonde, A. Lechner

thanking the contributions of A. Bertarelli, R. Bruce, P. Fessia, P. Hermes, A. Mereghetti, D. Mirarchi, S. Redaelli

7th HL-LHC Collaboration Meeting – Madrid – November 16th

CERN FLUKA EN STI

Outline

I. **Long straight section (LSS): cells 4-7**
   - **Motivation:** upgrade plans during LS2
   - **Integrated dose:** mitigation strategies
   - **Conclusions and outlooks**

II. **Dispersion suppressor (DS): cells 8-11**
   - **Motivation:** upgrade plans during LS2
   - **Peak power density:** quench risk evaluation
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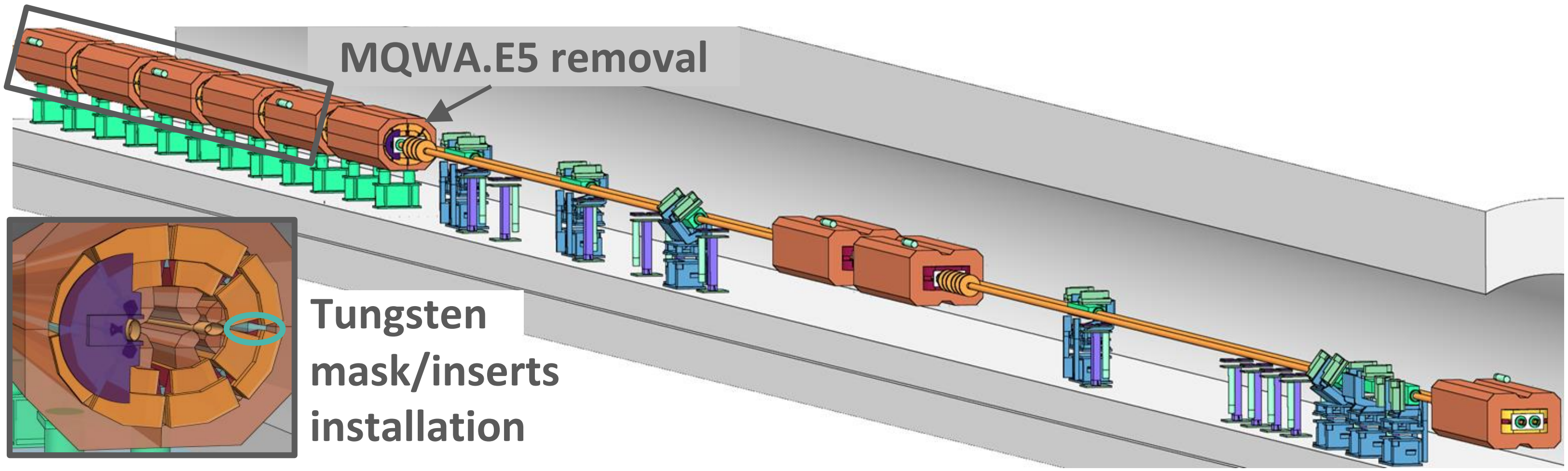
LSS upgrade plans in LS2

Long Straight Section (LSS): cells 4-7



Coils Spacers

Dose received by downstream MQWs during HL-LHC should remain as if MQWA.E5 stayed in place

Integrated dose evaluation assuming 1 x 10^{18} protons lost in IR7 for whole HL-LHC period → potential overestimation factor 12*

R. Garcia Alia, 7th HL-LHC Collaboration Meeting, 15/11/17

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Materials test results and dose limits

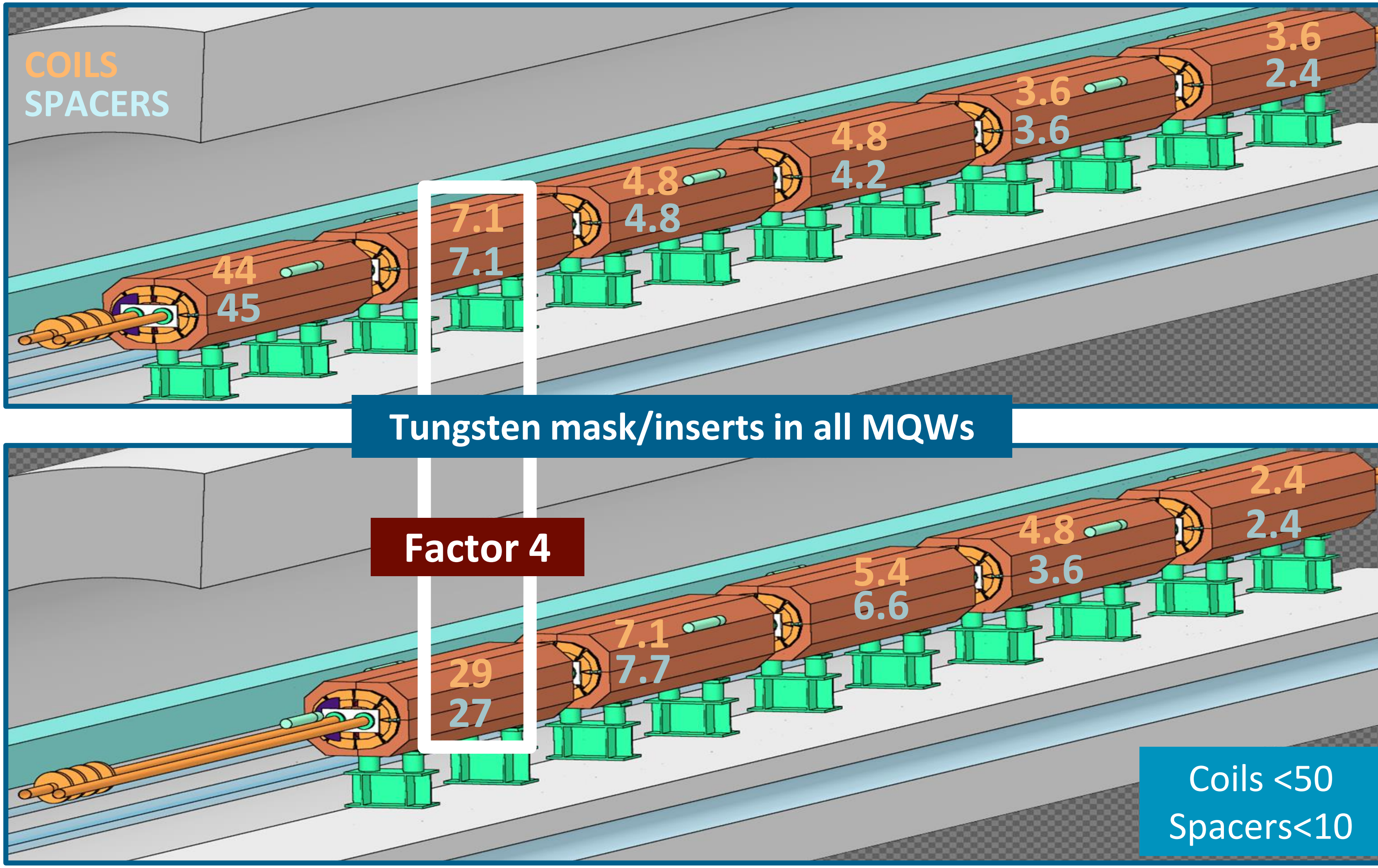
Dose limits (MGy) to not be surpassed **until the end of HL-LHC**

Material	Beginning of Damage (no bubbles, limited variation in properties)	Moderate Damage (bubbles formation and beginning of properties reduction)	Failure on Component (extensive bubbles, properties loss)
MQW Coils	10-50	50-75	>75
MQW Spacers	5-10 After: heavily damaged	10-15	>15

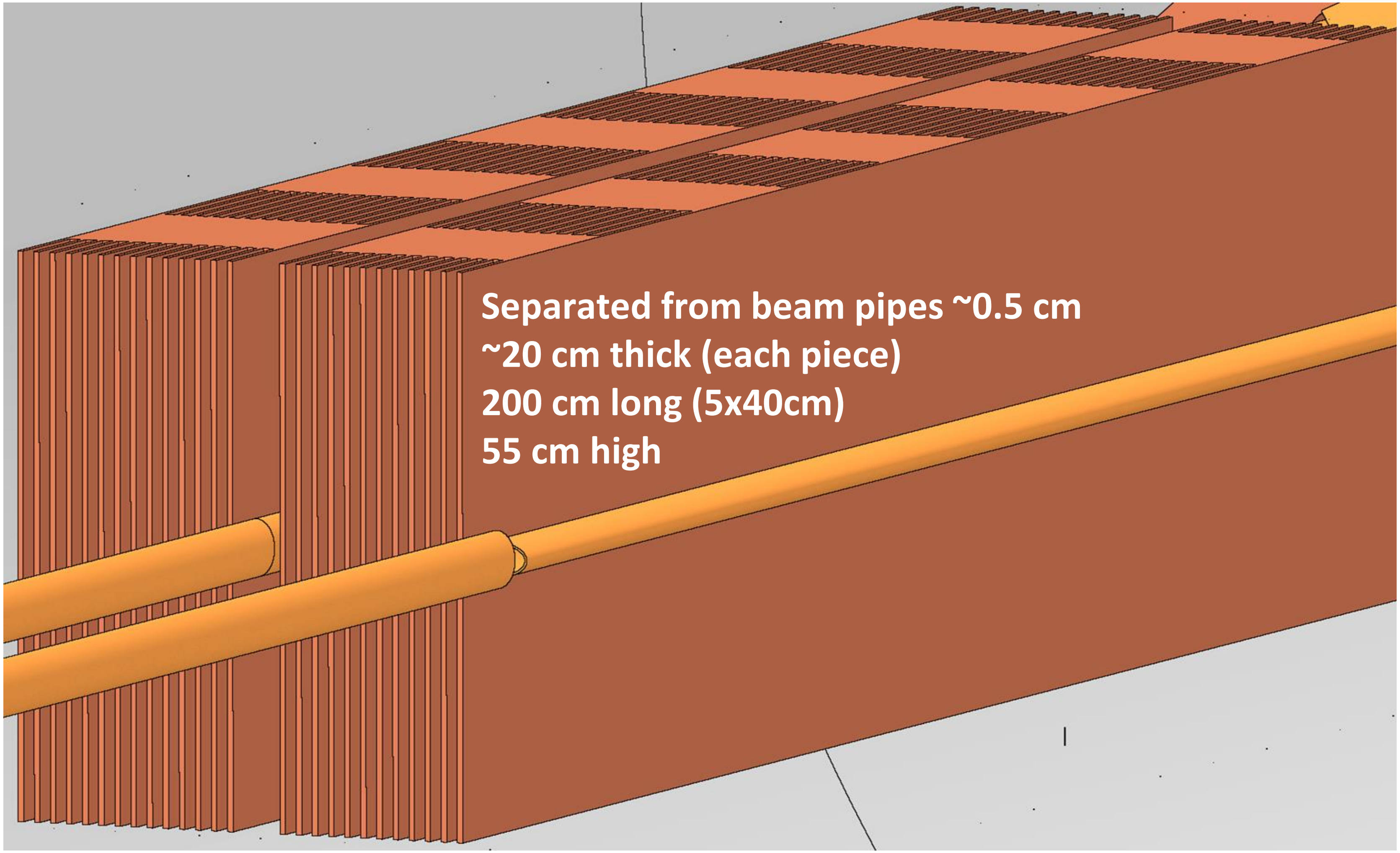
P. Fessia, Radiation levels of MBW and MQW, 14th HL-LHC TCC, 01/09/16

Coils <50
Spacers<10

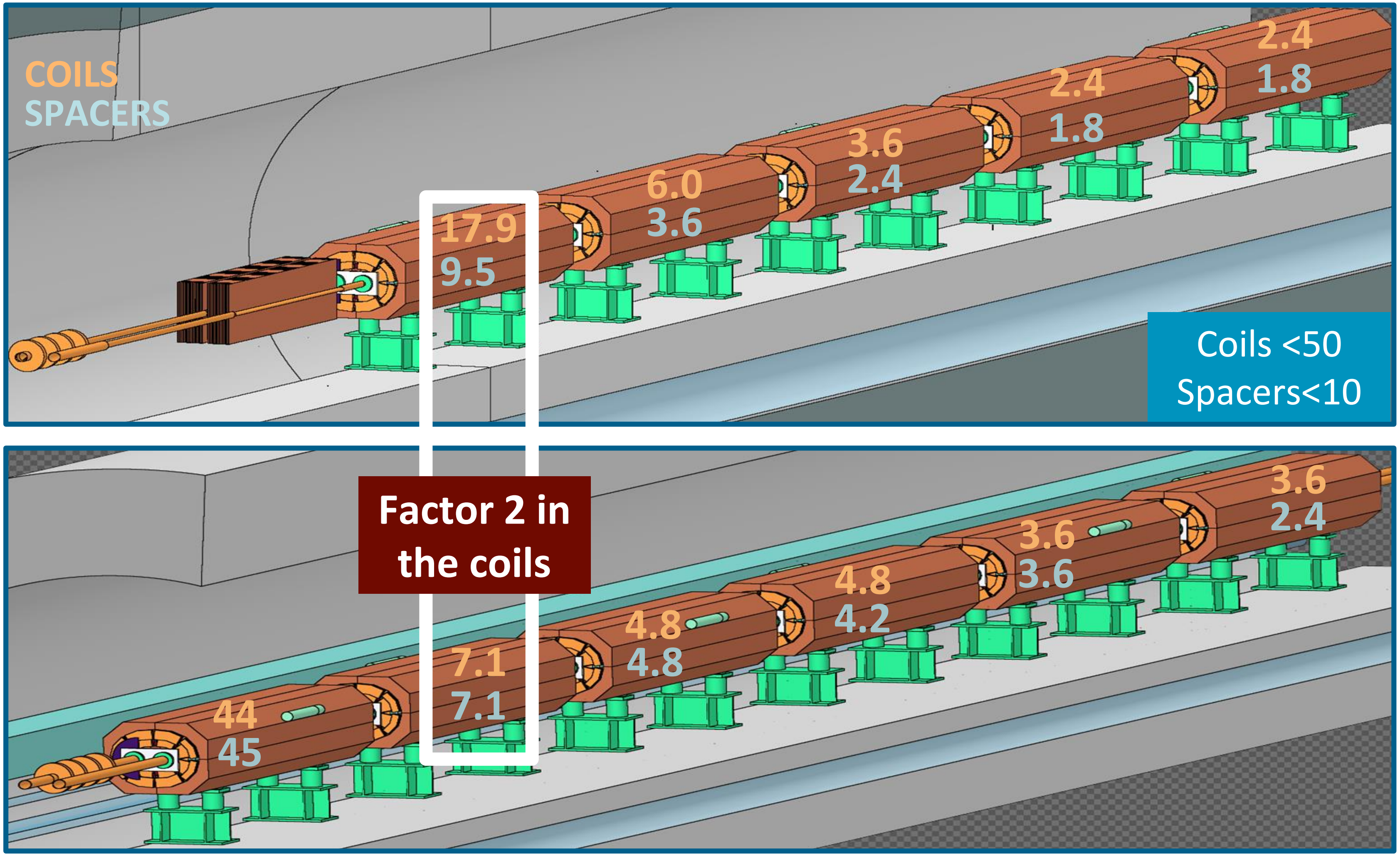
Peak dose with/without MQWA.E5 (MGy)



Passive protection: iron shielding



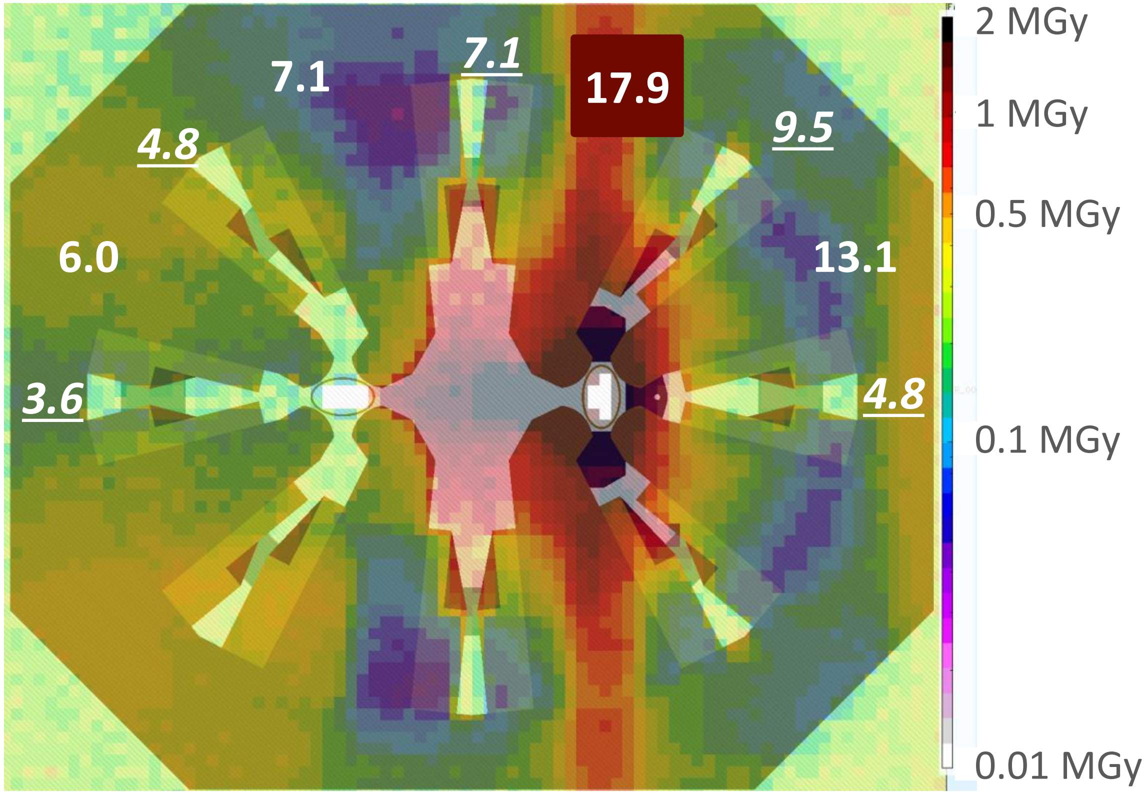
Peak dose with shielding (MGy)



Shielding limitations

Dose accumulated by most exposed magnet during all HL-LHC with improved passive protection installed (MGy)

- **Coils**
- ***Spacers***



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LSS conclusions and outlooks

- During HL-LHC in order to keep the **integrated dose** received by the **MQWs** of cell 5 as if the removed module stayed in, **additional passive protection** should be installed

- The **latest design** of this passive protection is still a factor of 2 **less effective as a shielding** than the removed MQW, barely allowing to comply with the material limits
  - **Further designs** will be evaluated in the near future

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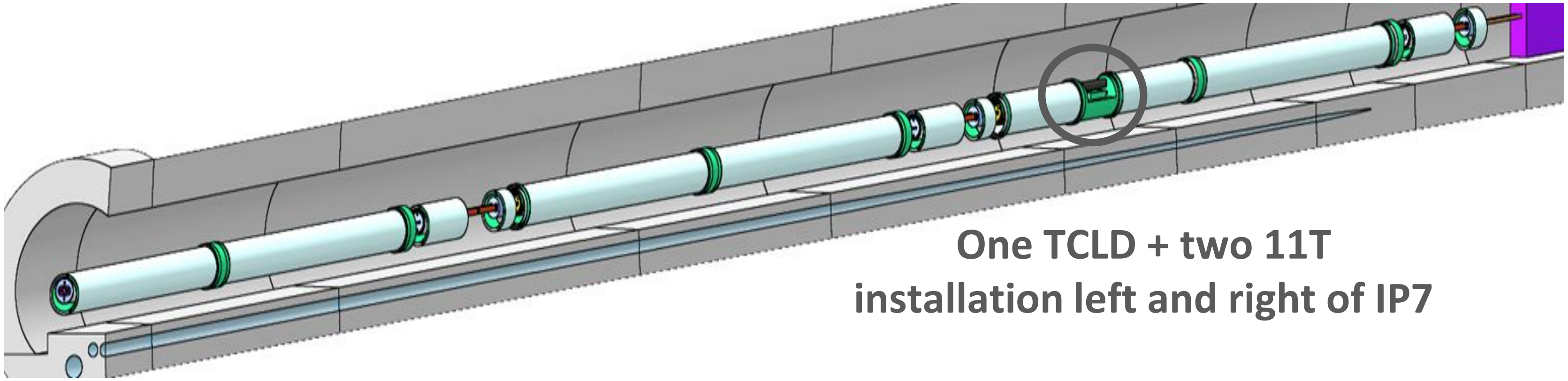
DS upgrade plans in LS2

Dispersion Suppressor (DS): cells 8-11



One TCLD + two 11T
installation left and right of IP7

Collimator position should be optimized between cells 8 and 9 to obtain the best cleaning balance both in proton and ion runs

Quench risk evaluation (energy deposition in the magnet coils) assuming losses of 7.9×10^{11} protons/s (1MW) lost in the collimation system and 3.64×10^{8} ions/s for 12 min beam life time

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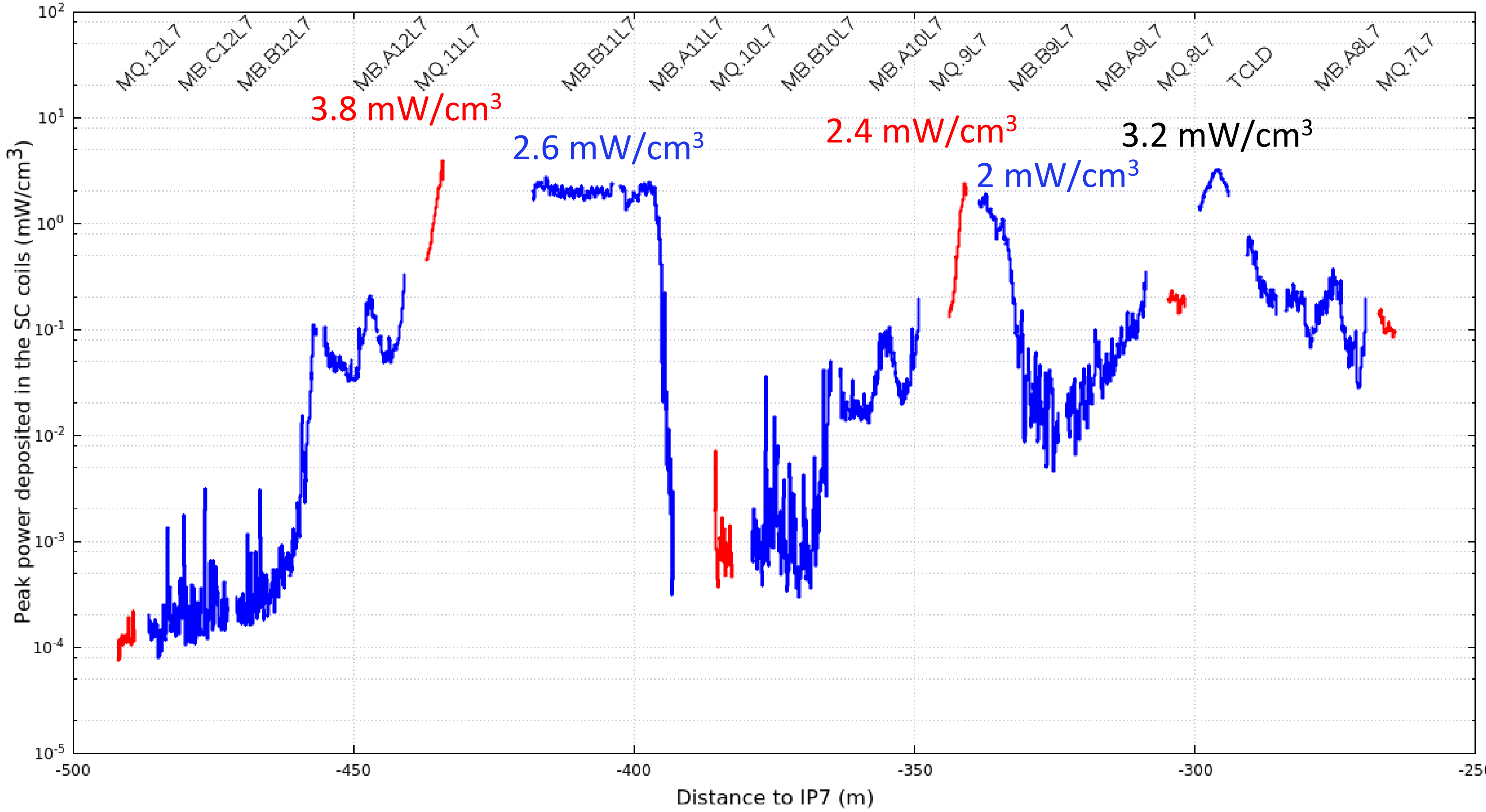
Peak power density profile in the DS



Peak power density for HL-LHC (mW/cm^3)

TCLD position	PROTONS					IONS				
	Cell 8/9			Cell 11		Cell 8/9			Cell 11	
	MB	*MQ*	*11T*	*MB*	*MQ*	*MB*	*MQ*	*11T*	*MB*	*MQ*
No TCLD	**6.3**	3.0	-	3.6	3.8	**19.4**	8.9	-	**19.4**	12.1
MBB.8	2.0	2.4	3.2	2.6	**3.8**	1.8	4.9	7.1	**11.8**	11.2
MBA.9	1.8	2.4	**14.2**	<0.1	<0.1	2	1.2	**11.2**	<0.001	<0.001
MBB.9	6.3	3.0	**15.5**	<0.1	<0.01	4.5	3.9	**27.8**	<0.1	<0.001

If the quench limit of the 11T is found to be lower than other superconducting magnets, MBB.8 position would be better for ions

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DS conclusions and outlooks

Proton runs

- The TCLD may only help if placed in **MBB8** (50% reduction in Cell 8/9 and almost no reduction in Cell 11 compared to not having a TCLD).

Ion runs

- **TCP impact parameter** can influence a lot the energy density in the DS.
- When the TCLD is in **MBB8** position, a factor of 5 reduction could be achieved in cell 8/9 and a 30% reduction in cell 11. When in **MBA9** position a 40% reduction shows in cell 9 and really good cleaning in cell 11. Both positions are eligible **depending on 11T quench limit**.

Proton and ion runs

- **TCLA settings** can influence a lot the DS peak energy density in Cell 8/9.
- Previous benchmarks showed a factor 3 underestimation with respect to BLM measurements → **certain margin should be taken into account**.

Thank you for your attention

Back-up

LSS simulation parameters

Parameters of the study

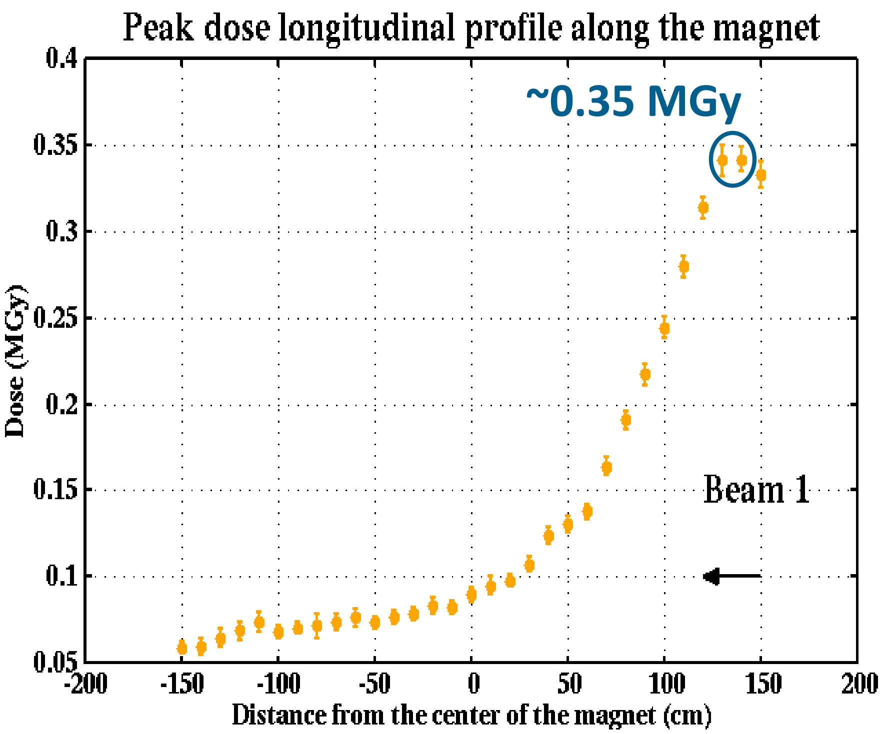
MQW section of cell 5 (most restrictive)

Horizontal halo (comparable for vertical)

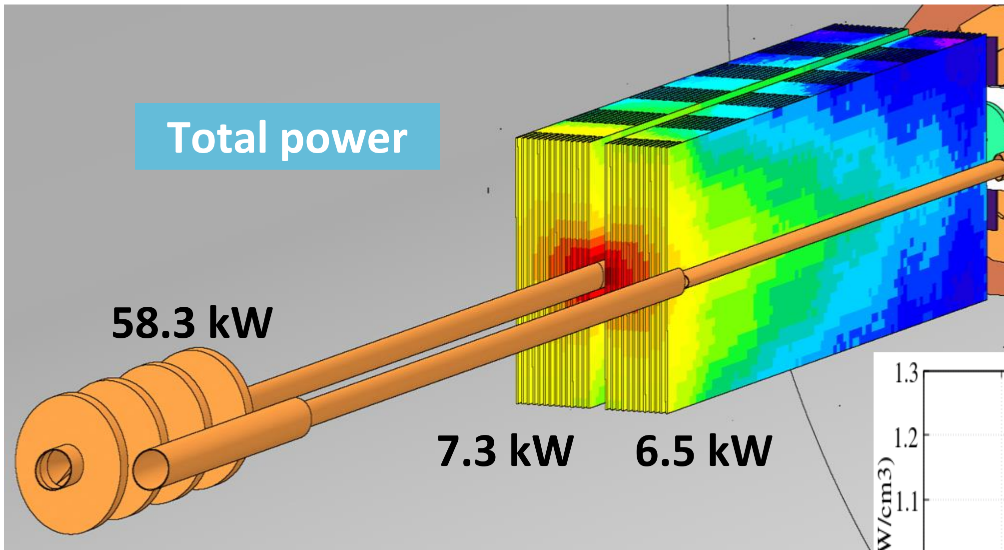
Beam 1: left from IP7 (symmetric for B2)

7 TeV, 40 cm β*, 205 μrad crossing, in collision

Obtention of results



LSS power load shielding



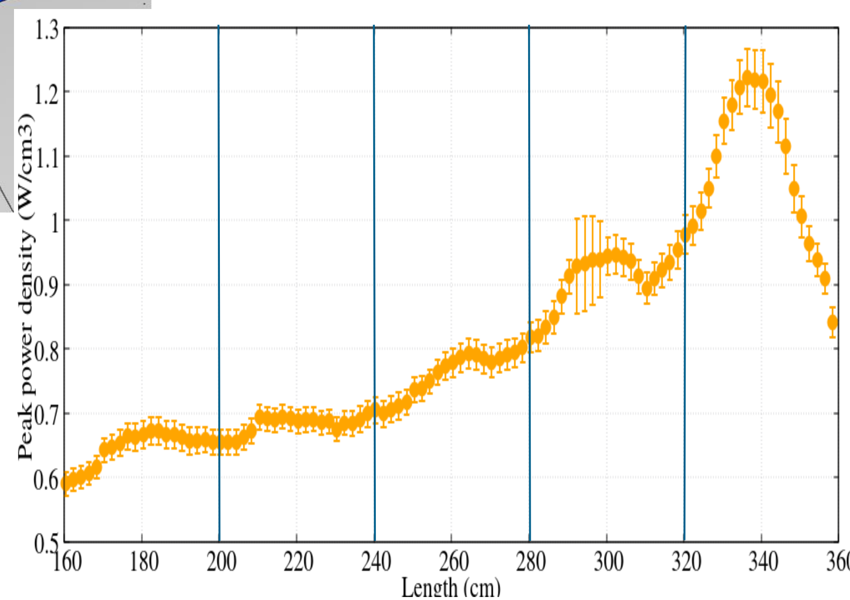
Assuming 7.9 x 10^{11} protons lost per second in IR7 during HL-LHC

(BLT of 12 minutes)

Peak power

1.9 W/cm^3 outer piece

1.8 W/cm^3 middle piece



DS simulation parameters

Protons and Pb ions

- 7Z TeV, HL-LHC optics

- B2, Horizontal case

Collimator materials in FLUKA model

TCP, TCSG in CFC

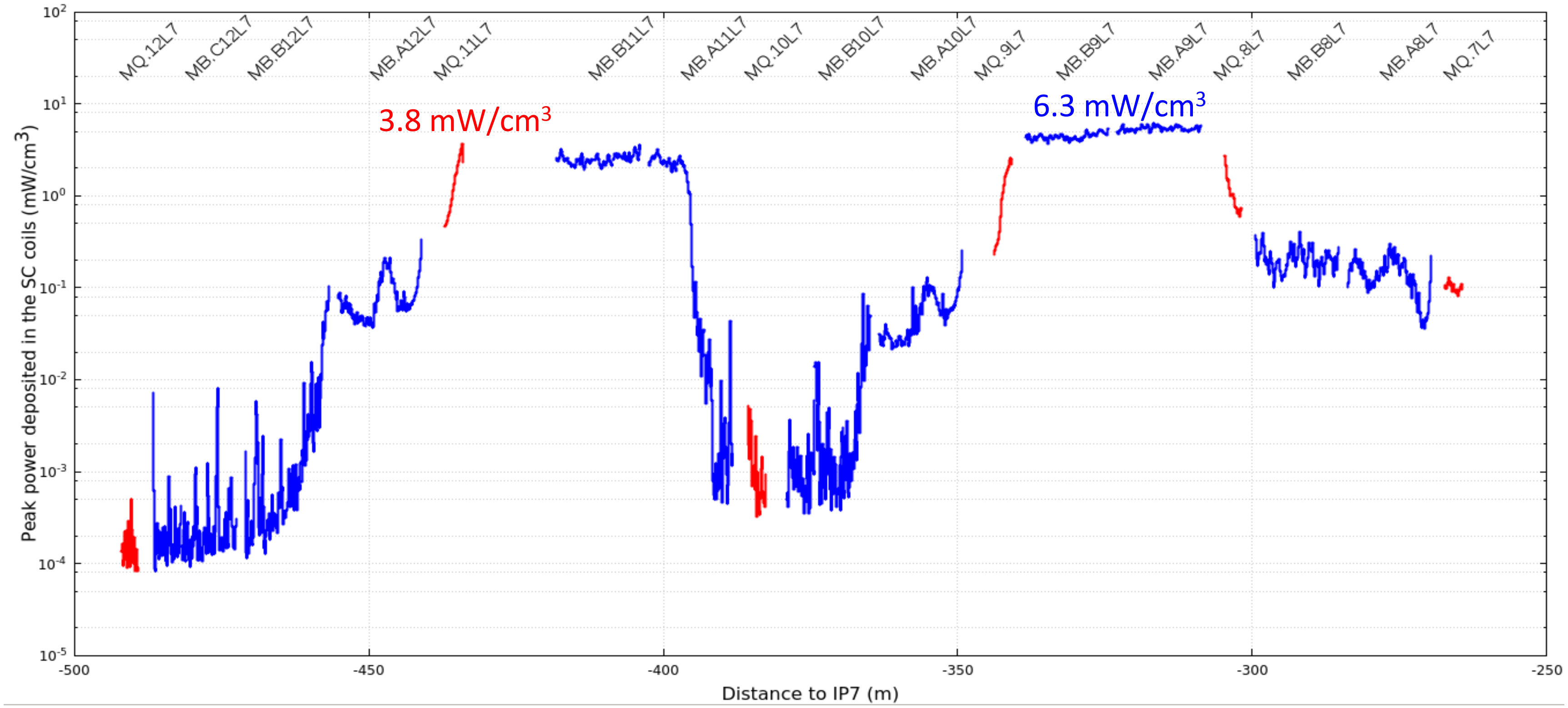
TCLA, TCLD (when used) in inermet 180

DS collimator settings

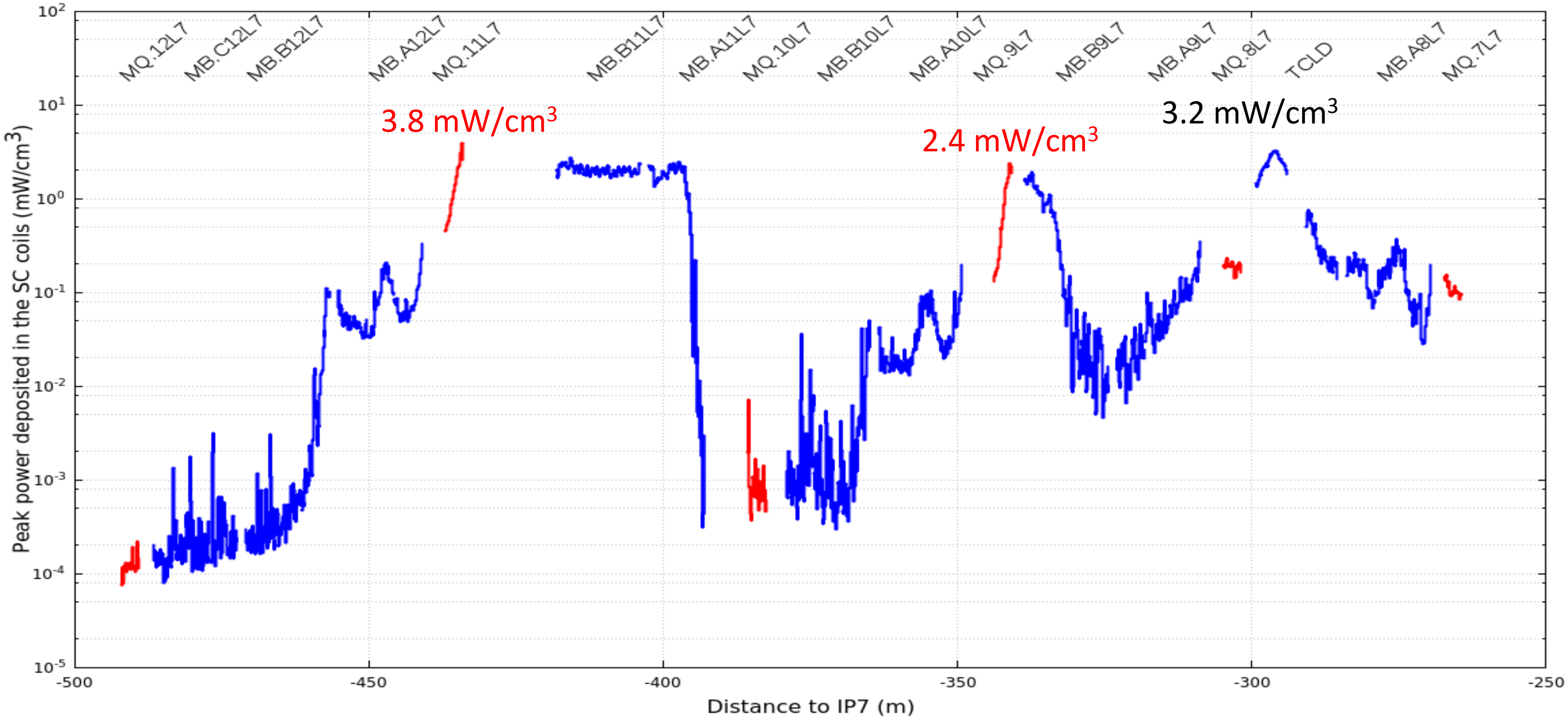
Proton studies		
TCP	5.7 sigma	2 sigma retraction (TCP–TCSG)
TCSG	7.7 sigma	
TCLA	10 sigma	4.3 sigma retraction (TCSG–TCLA)
TCLD (when used)	14 sigma	

Ion studies		
TCP	6 sigma	1 sigma retraction (TCP–TCSG)
TCSG	7 sigma	
TCLA	10 sigma	4 sigma retraction (TCP–TCLA)
TCLD (when used)	14 sigma	

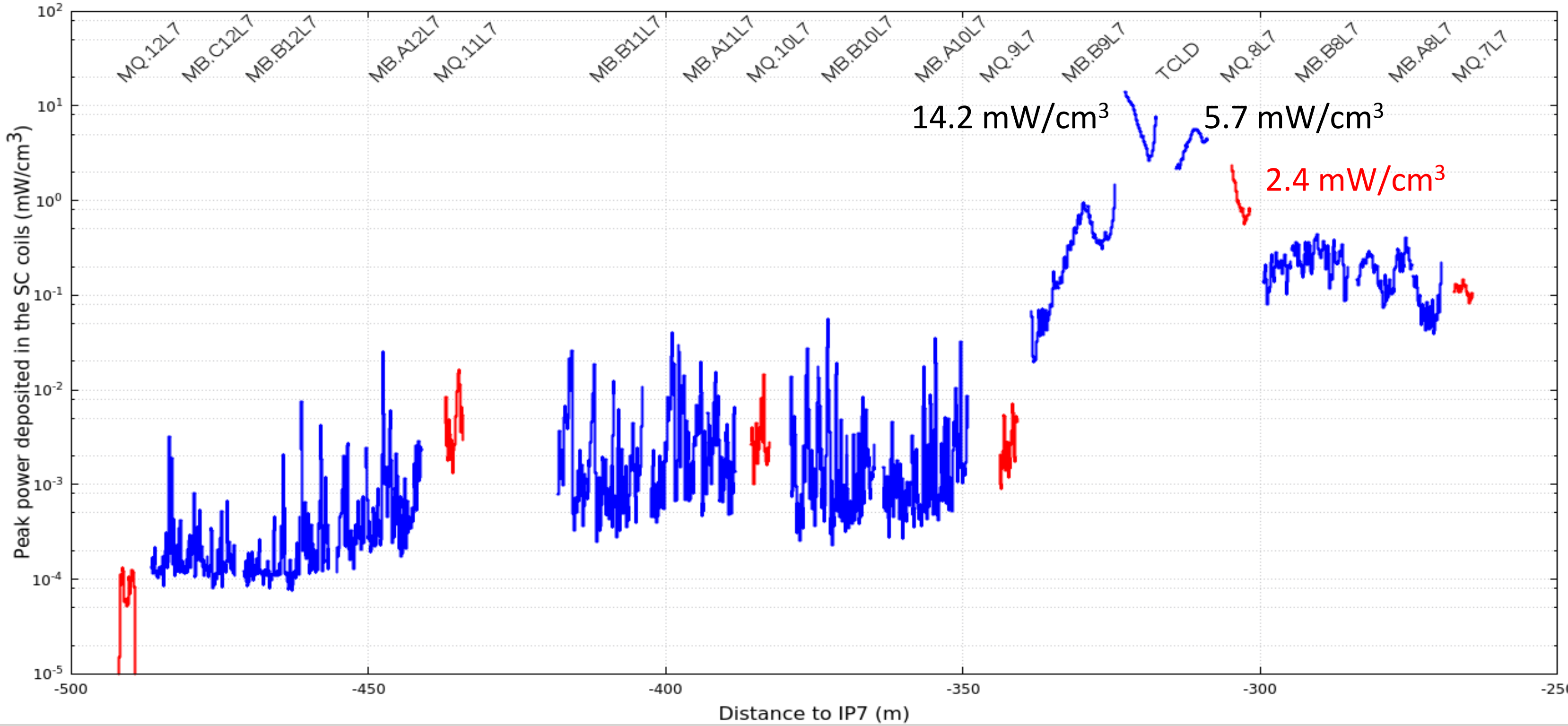
Protons: no TCLD



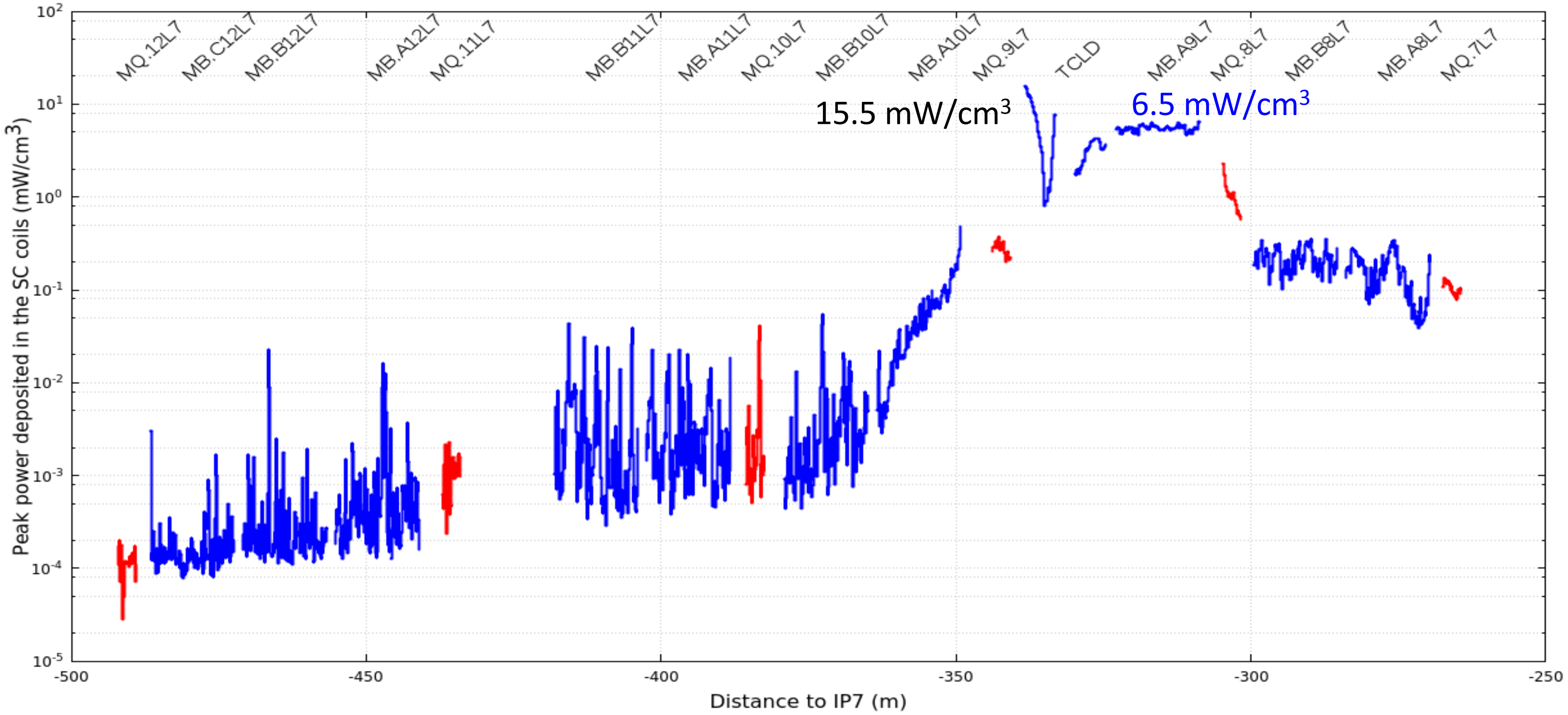
Protons: TCLD in MBB.8



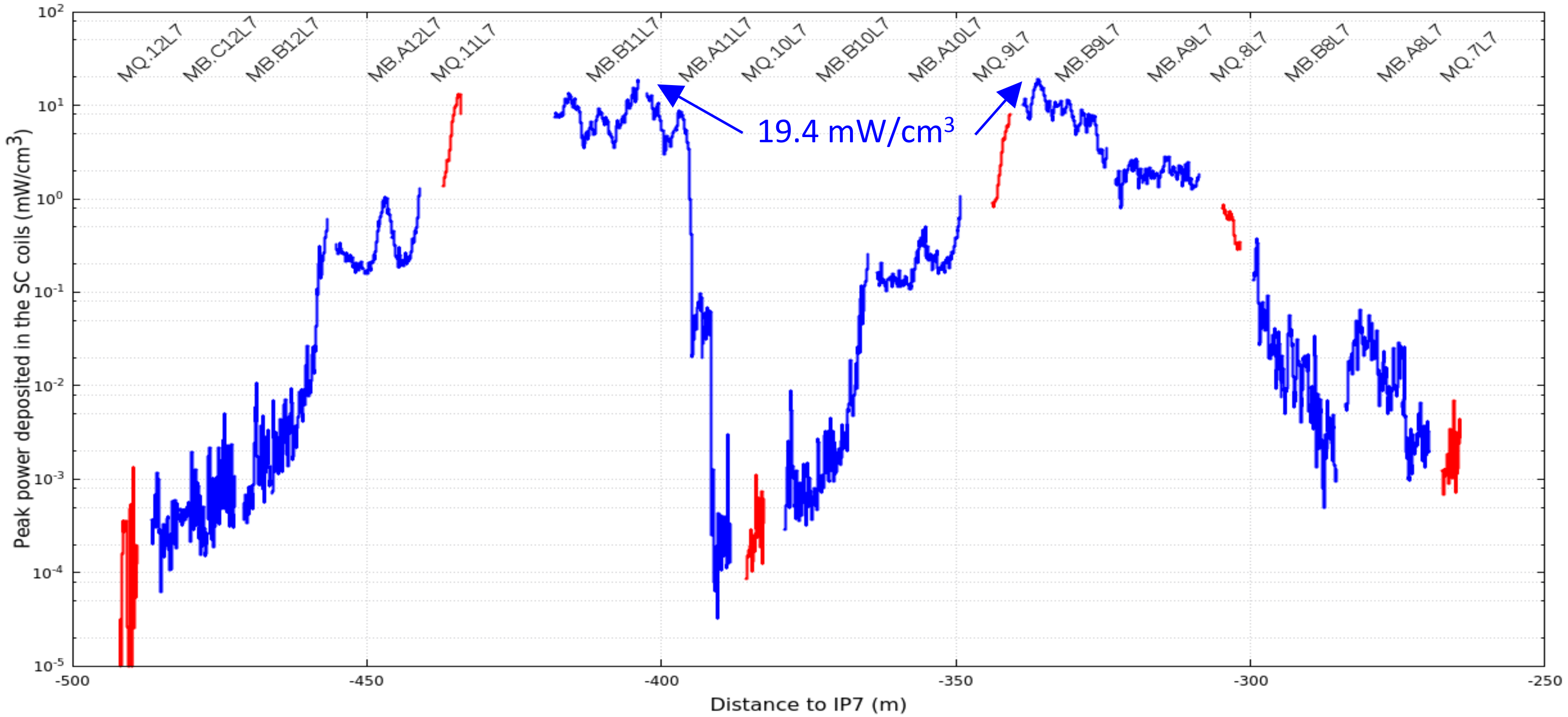
Protons: TCLD in MBA.9



Protons: TCLD in MBB.9

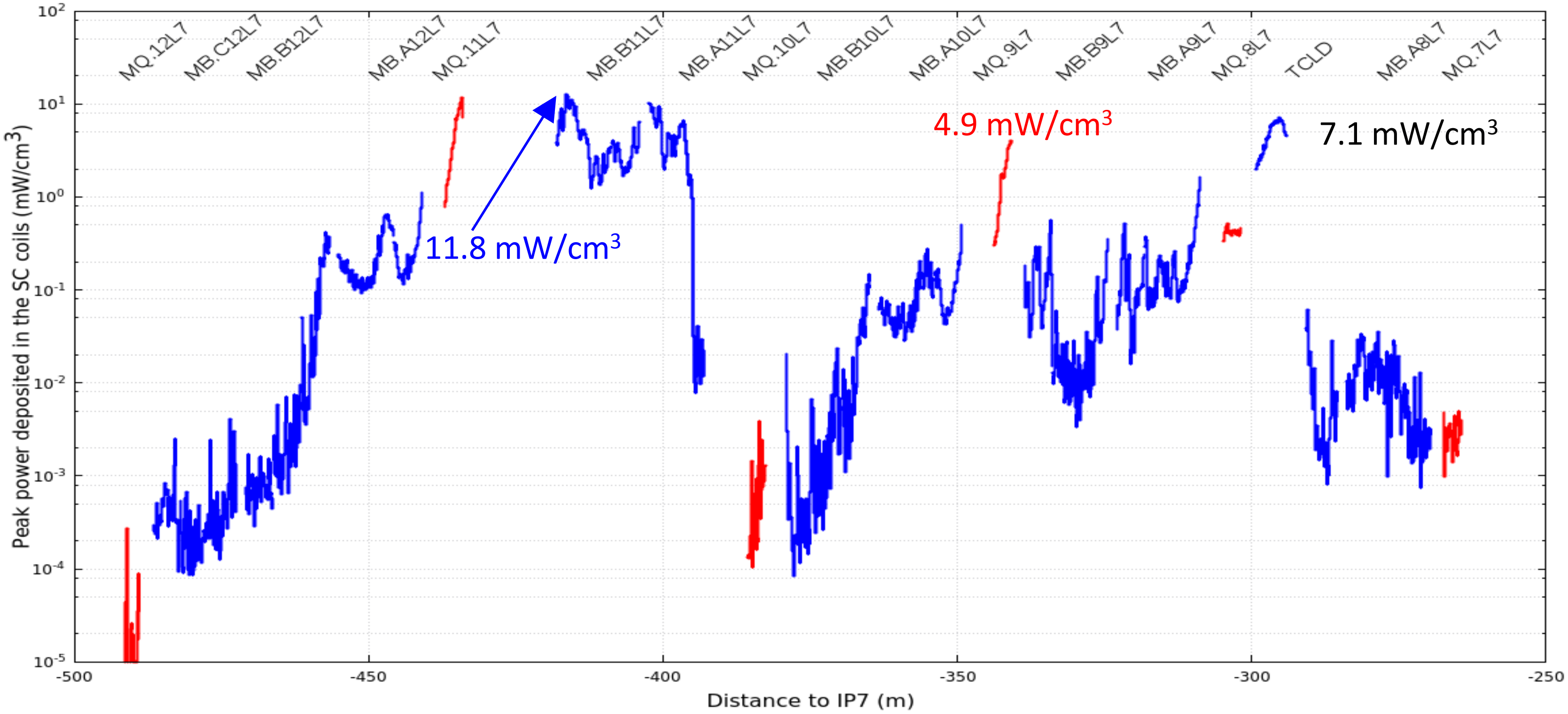


Ions: no TCLD



MQ.12L7
MB.C12L7
MB.B12L7
MB.A12L7
MQ.11L7
MB.B11L7
MB.A11L7
MQ.10L7
MB.B10L7
MB.A10L7
MQ.9L7
MB.B9L7
MB.A9L7
MQ.8L7
MB.B8L7
MB.A8L7
MQ.7L7
19.4 mW/cm3
Peak power deposited in the SC coils (mW/cm3)
Distance to IP7 (m)
-500
-450
-400
-350
-300
-250

Ions: TCLD in MBB.8



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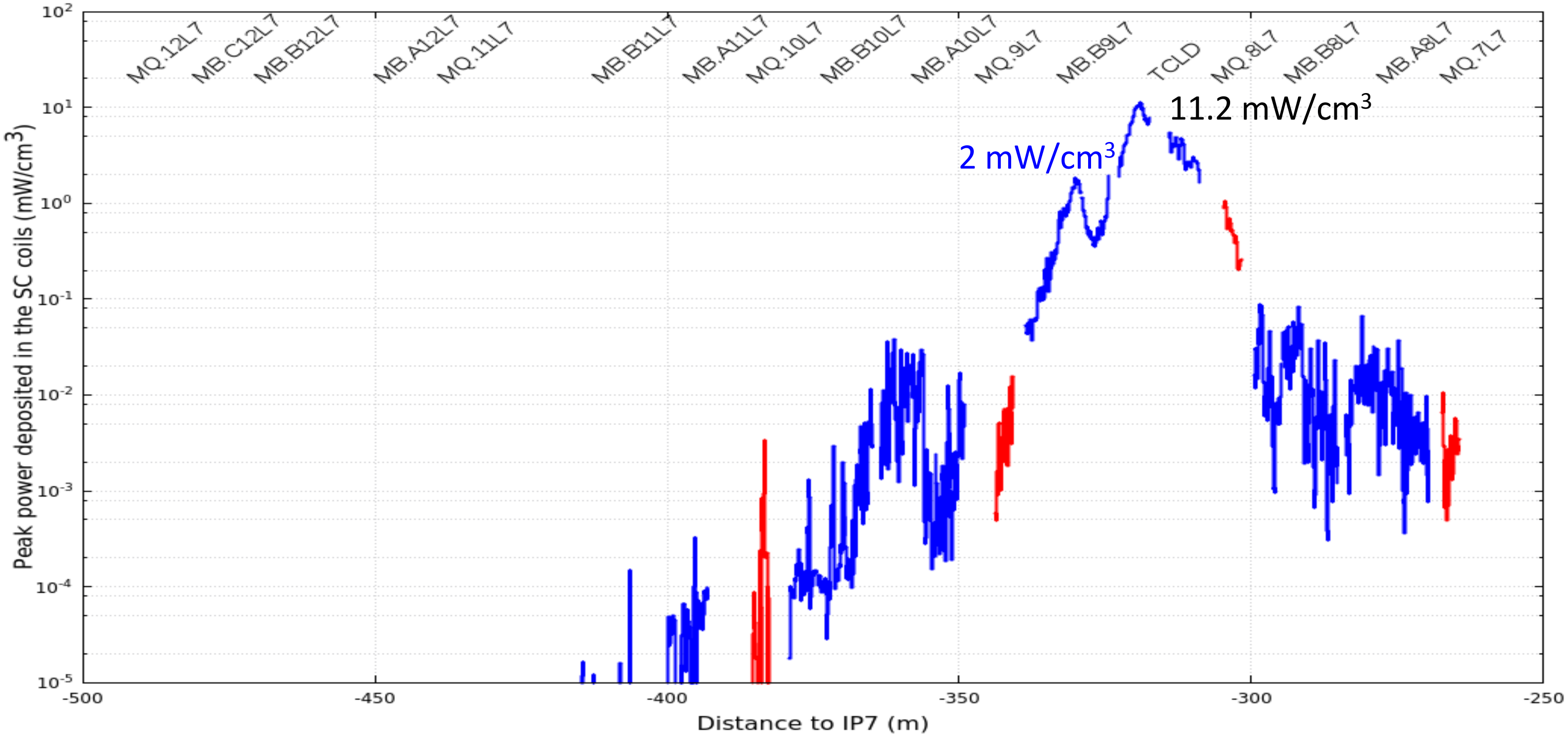

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