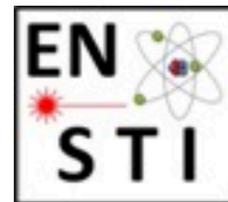




Radiation levels in the IR2-IR8 tunnel and shielded alcoves

WP10
Energy Deposition & R2E



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with input from C.Bahamonde Castro, K.Bilko, M.Mendes, A.Ciccotelli, L.Esposito

Review of HL-LHC radiation level specification document

12th December 2019

Introduction

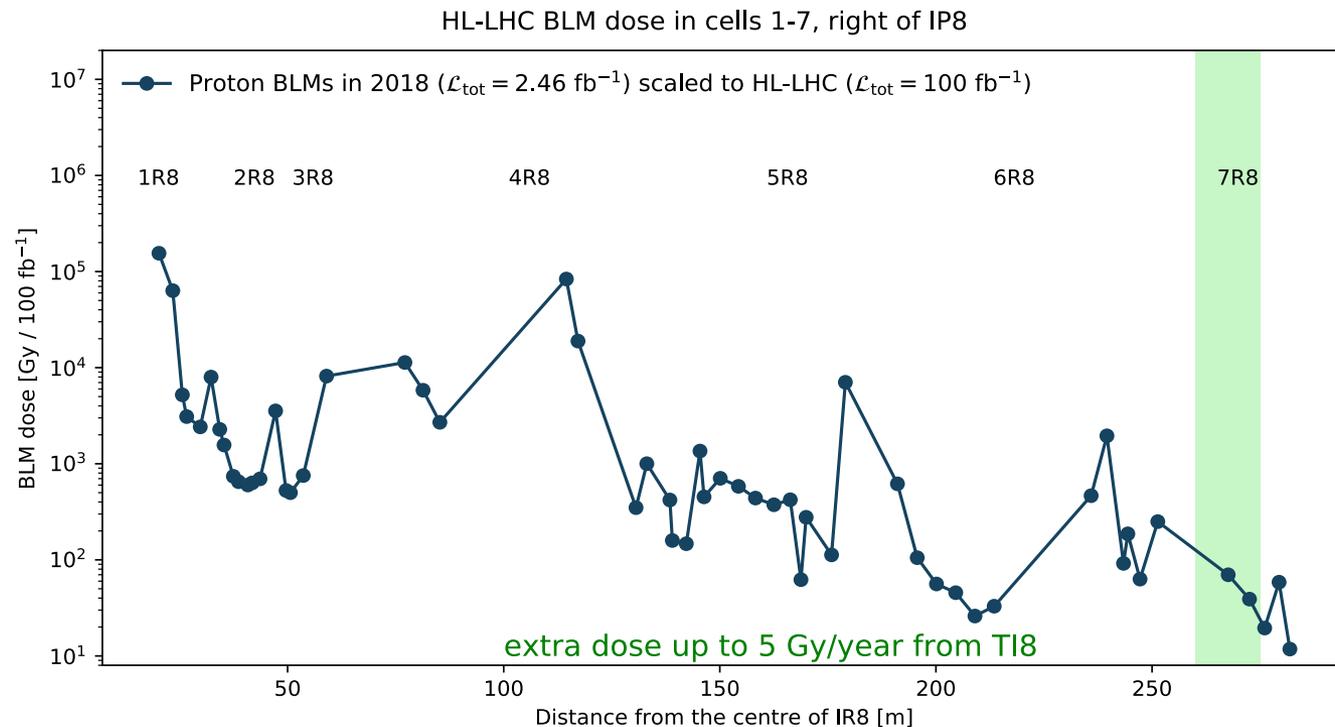
- IR2 and IR8 hosts the ALICE and LHCb experiments.
- In addition, they also host the merging of the TI2 and TI8 injection lines into the LHC tunnel (in the DS).
- For IR8, HL-LHC specifications are available for both proton and ion operation. At the moment they are based only on rescaled Run 2 measurements (but new FLUKA simulations are planned).
- For IR2 we have a FLUKA simulation by C.Bahamonde Castro which evaluates the impact of newly-installed TCLD collimators in half-cell 11. The final definition of the specifications is still in progress (see second part of the presentation).

IR8: luminosity-driven radiation levels

- The radiation levels in IR8 have been discussed in a recent [presentation at the 39th MCWG meeting](#).
- HL-LHC integrated luminosity predictions:
 - 50 fb⁻¹ in Run 3+4 (~ 7 fb⁻¹ / year, up by a factor ~3 with respect to the 2.46 fb⁻¹ in 2018).
 - Possible new upgrade in LS4, further increasing the luminosity to 50 fb⁻¹ / year. We neglect this, and we assume a total of **100 fb⁻¹ for the full HL-LHC period** (i.e. assuming only 50 fb⁻¹ more after LS4).
 - For ion operation we assume **1.5 nb⁻¹ for the full HL-LHC period** (as opposed to 0.23 nb⁻¹ in 2018).

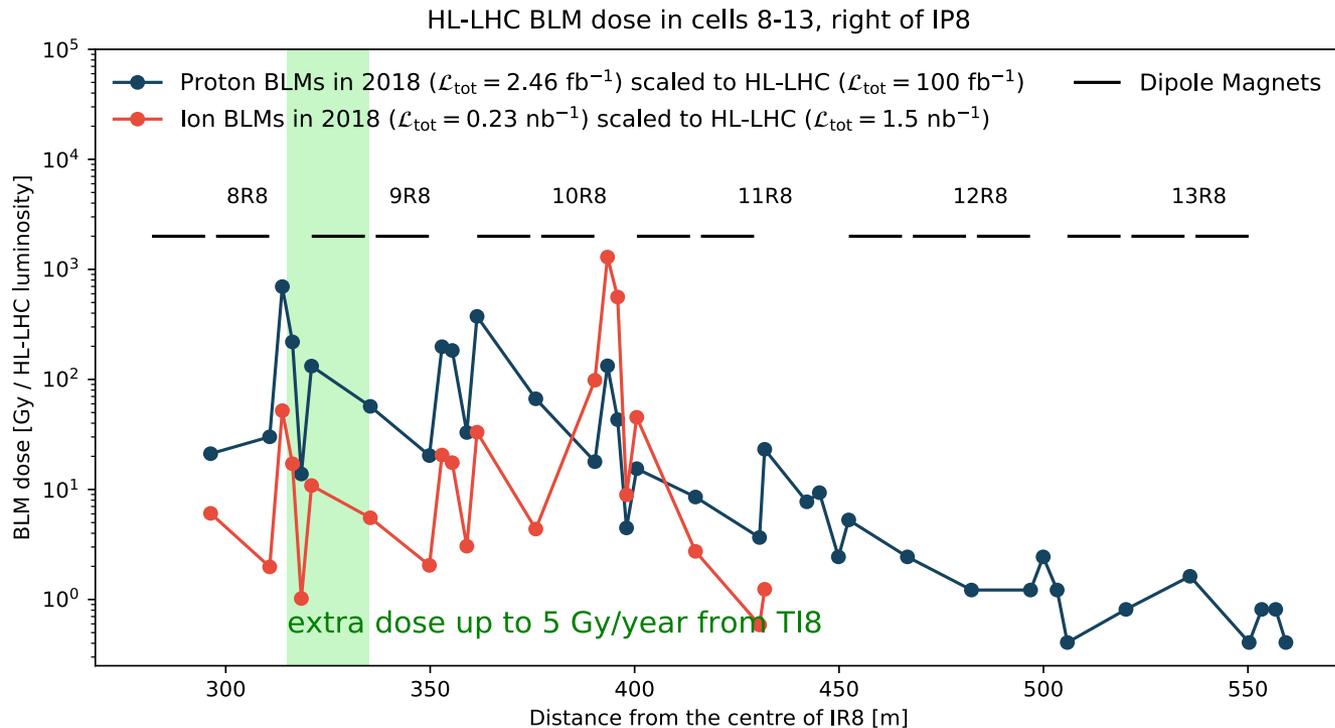
Radiation levels in the LSS of IP8

- 2018 BLM profile rescaled to the full HL-LHC operation. Only proton runs are relevant in the LSS.
- A FLUKA simulation (A.Ciccotelli, L.Esposito) of post-LIU T18 losses at the end of T18 (i.e. in UJ88) allows to set an upper limit of 5Gy/year from injection losses in the green area below.



Radiation levels in the DS of IP8

- 2018 BLM TID profile rescaled to the full HL-LHC period. Both proton and ion runs are relevant in the DS. Extra 5 Gy/year from injection losses in the green area.
- Note: TID at rack position (floor level) typically 2-3 times lower than at BLM position (on beamline elements).



HL-LHC specifications in the IR8 DS

- The specifications for the DS of IR8 are extracted from the rescaled DS distribution in the previous slide, based on the same A-B-C-D categories used for IR1-IR5 DS.
- Caveat: in IR8 the left and right side of the DS are asymmetric, because on the right side there is the end of the TI8 injection line.

	TID [Gy]	HEH [cm^{-2}]	Th. neut. [cm^{-2}]	1MeVn-eq [cm^{-2}]
Category A	< 50	< $5 \cdot 10^{10}$	< $5 \cdot 10^{11}$	< $5 \cdot 10^{11}$
Category B	< 200	< $2 \cdot 10^{11}$	< $2 \cdot 10^{12}$	< $2 \cdot 10^{12}$
Category C	< 1000	< $1 \cdot 10^{12}$	< $1 \cdot 10^{13}$	< $1 \cdot 10^{13}$
Category D*	> 1000	> $1 \cdot 10^{12}$	> $1 \cdot 10^{13}$	> $1 \cdot 10^{13}$

HL-LHC specifications in the IR8 DS: results / 1

- For half-cells 8-9-10-11 the right/left specifications are given separately due to the asymmetric IR8 layout.
- Half-cell 9R8 includes the injection contribution (TI8)

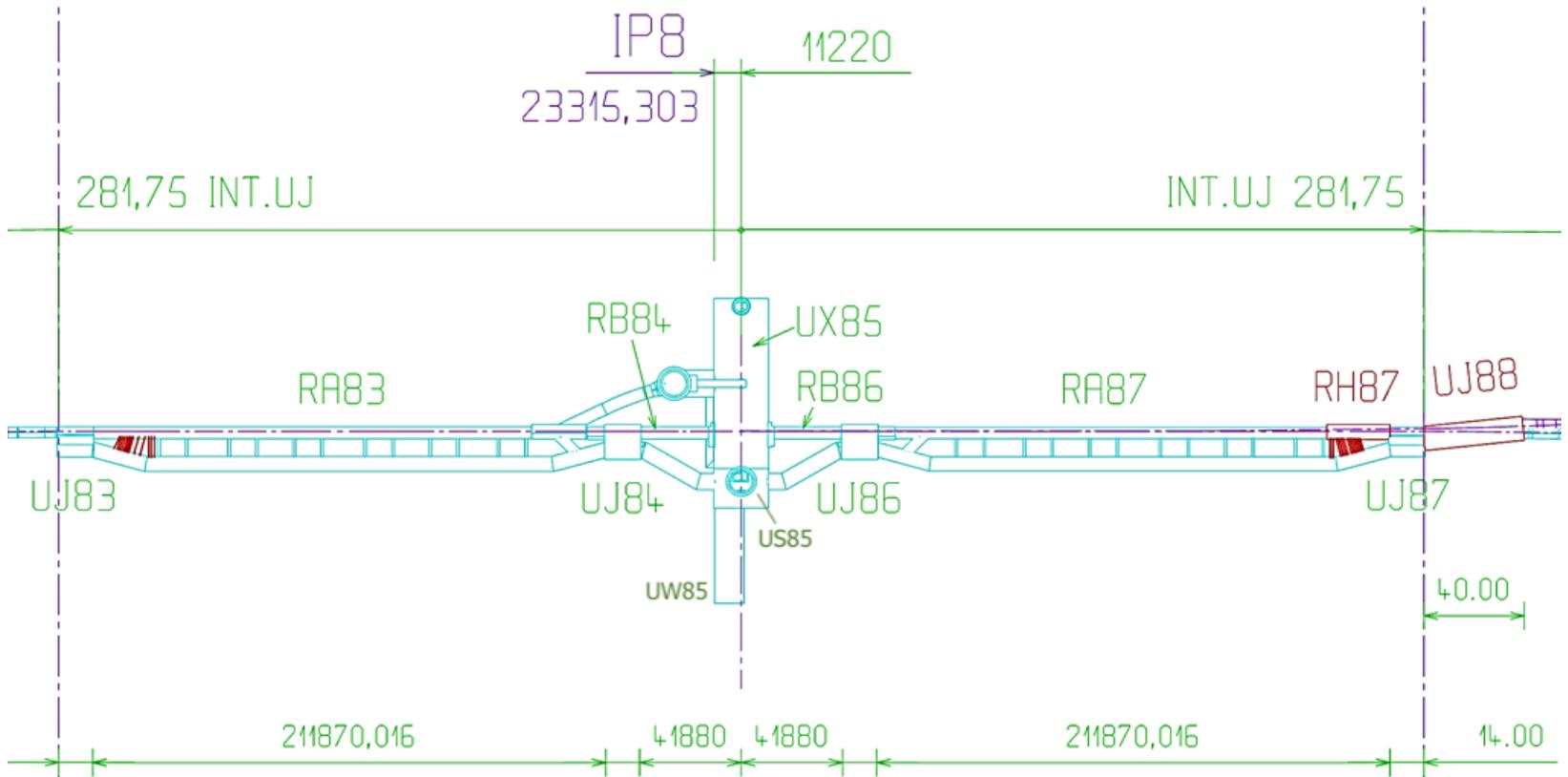
	z (distance from IP) range	Radiation level category
half-cell 8 (left)	$-288 < z < -258$	B
	$-297 < z < -288$	C
half-cell 8 (right)	$280 < z < 310$	B
	$310 < z < 320$	C
half-cell 9 (left)	$-328 < z < -297$	B
	$-338 < z < -328$	C
half-cell 9 (right)	$320 < z < 335$	C*
	$335 < z < 350$	B
	$350 < z < 360$	C
half-cell 10 (protons)	both left-right	B

HL-LHC specifications in the IR8 DS: results / 2

	z (distance from IP) range	Radiation level category
half-cell 10 (ions-left)	$-355 < z < -338$	A
	$-363 < z < -355$	B
	$-375 < z < -363$	D
	$-377 < z < -375$	B
half-cell 10 (ions-right)	$360 < z < -375$	A
	$375 < z < 390$	B
	$390 < z < 397$	D
	$397 < z < 399$	B
half-cell 11 (protons)	both left-right	A
half-cell 11 (left-ions)	$-385 < z < -377$	B
	$-429 < z < -385$	B
half-cell 11 (right-ions)	$399 < z < 405$	B
	$405 < z < 450$	A
half-cell 12	all (left-right)	A
half-cell 13	all (left-right)	A

IR8 layout

- HL-LHC specifications are currently provided for the UL84, UX85 and US85 alcoves.



layout provided by M.Mendes

IR8 shielded alcoves

- The radiation levels in UX85, US85 and UL84 are affected by the fact that the LHCb detector is not hermetic → significant leakage from the experimental cavern in all directions (unlike ATLAS and CMS, where the leakage occurs mostly in the forward direction).
- At present, the only FLUKA simulation covering the whole LHCb cavern and nearby alcoves dates back to 2010, and the layout is not fully up to date → we do not use it for HL-LHC predictions.
- The specifications are extracted from Run 2 RadMon measurements scaled to HL-LHC integrated luminosity.
- A PhD student (A.Ciccotelli) will work on a new FLUKA simulation of these areas (starting in spring).

IR8 shielded alcoves: HL-LHC specifications

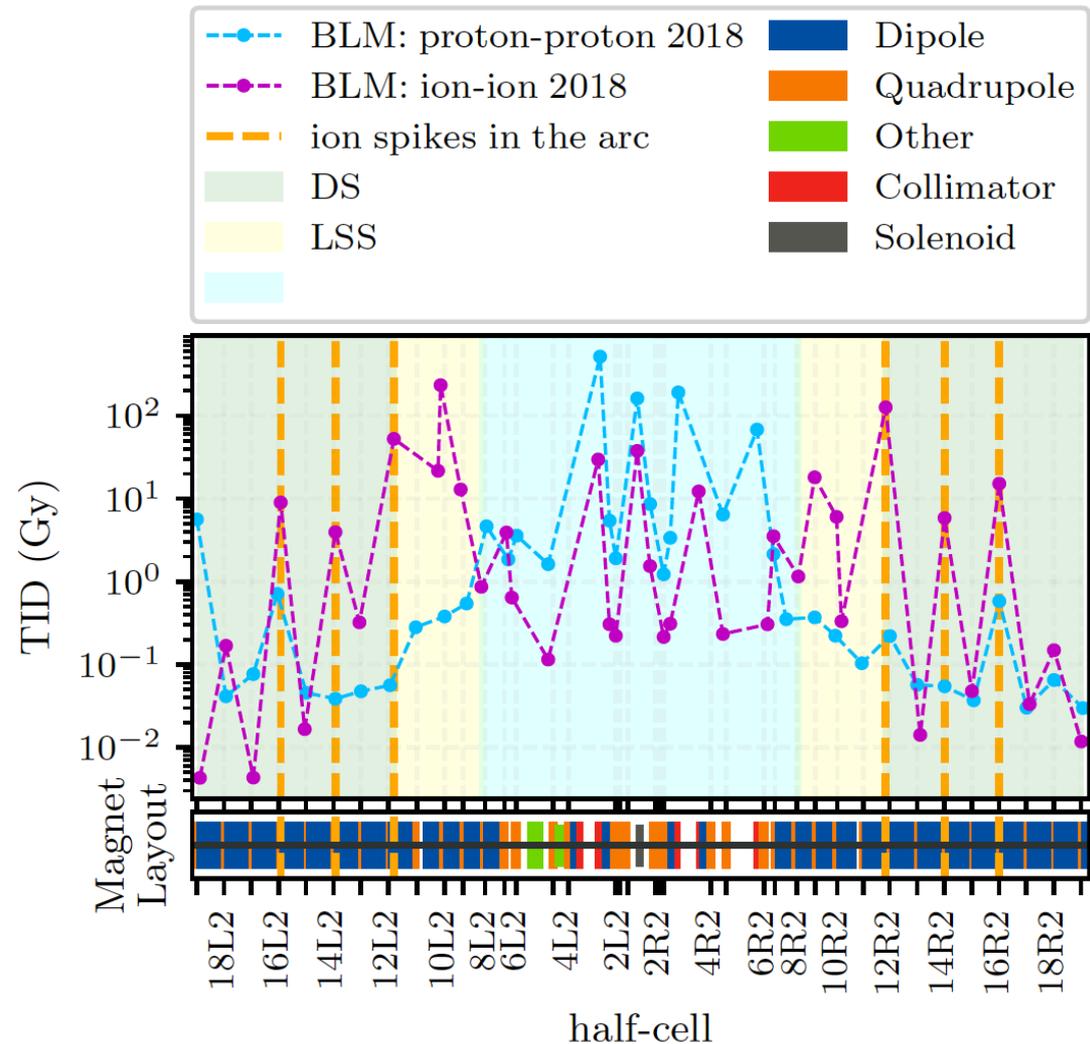
- We focus on HEH fluence specifications (from RadMons).
- UX85 specifications derived from the RadMon with the highest Run 2 measurement (6 RadMons in total in UX85, all measuring HEH fluences compatible within a factor 3).
- Due to the asymmetric layout of LHCb, the UL84 levels are not representative of UL86 (no RadMon there at present).
- No RadMon also in UW85 → no specifications available.

	RadMon	2018 HEH (cm^{-2})	HL-LHC HEH (cm^{-2})
UX85 (max. RadMon)	SIMA.UX85.8LE07S	$6.0 \cdot 10^8$	$2.5 \cdot 10^{10}$
UL84	SIMA.UL84.8LE03S	$1.5 \cdot 10^7$	$7.5 \cdot 10^8$
US85 (L0)	SIMA.US85.8LE01S	$1.6 \cdot 10^7$ (*)	$6.5 \cdot 10^8$
US85 (L1)	SIMA.US85.8LE05S	$1.4 \cdot 10^8$	$5.8 \cdot 10^9$
US85 (L2)	SIMA.US85.8LE11S	$4.3 \cdot 10^7$	$1.8 \cdot 10^9$

IR2: BLM levels in 2018

- BLM levels during 2018 for proton and ion runs in IR2.
- Main message: the levels in the LSS (i.e. also in the nearby shielded areas) are dominated by proton runs. From the DS onwards (including partially the arcs) they become dominated by proton runs.

K. Bilko, RADECS 2019 (submitted to IEEE)

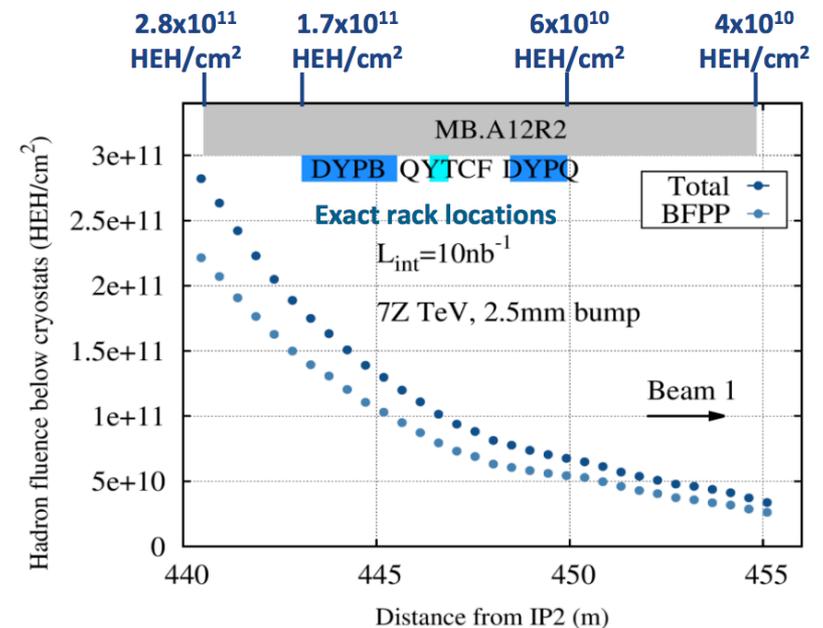
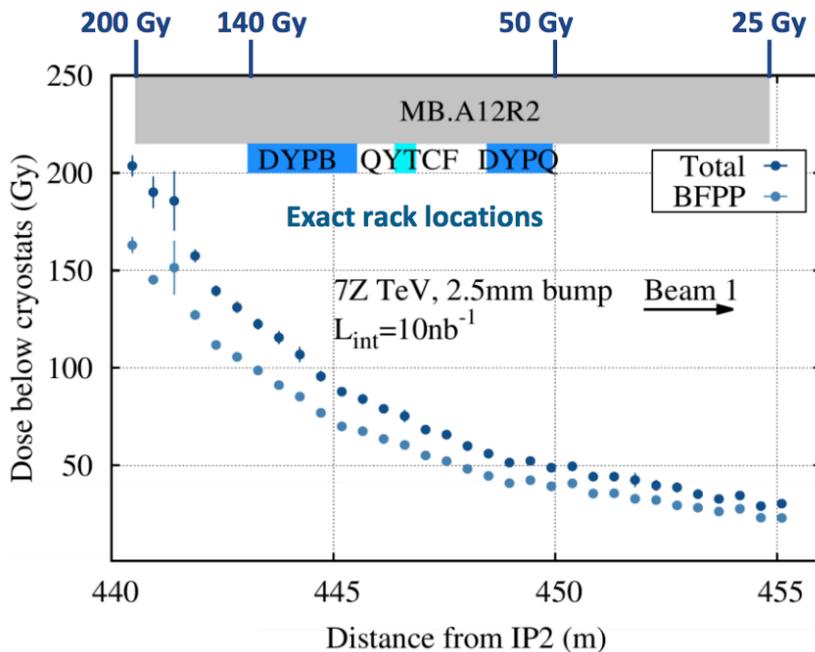


IR2 specifications: present situation

- Work in progress for HL-LHC specifications in IR2.
- Main considerations:
 - The IR2 **proton luminosity** is lower compared to other IPs (**$<0.03 \text{ fb}^{-1}$ in 2018**). Still, it is important to know how this will scale in HL-LHC because the radiation levels in the LSS (so also in the shielded areas) are dominated by proton runs. If the luminosity increases, proton losses may become relevant also in the DS.
 - For **HL-LHC ion runs** we expect **10 nb^{-1}** (as much as ATLAS and CMS). The Run 2 DS levels up to half-cell 11 can be obtained from BLMs scaled with integrated luminosity. New (TCLD) collimators will be installed in half-cell 11 → FLUKA simulation needed for this region.

FLUKA simulation of TCLD losses (half-cell 11)

- FLUKA simulation by C.Bahamonde Castro ([see 14th TCC presentation](#)) of TID and HEH at floor level near the TCLD.
- BFPP (and other ion-related) losses cause significant radiation levels below the MB.A12 (up to ~ 200 Gy/10 nb⁻¹).
- We plan to use the profiles below (with larger longitudinal range) to define HL-LHC IR2 DS specifications beyond half-cell 11.

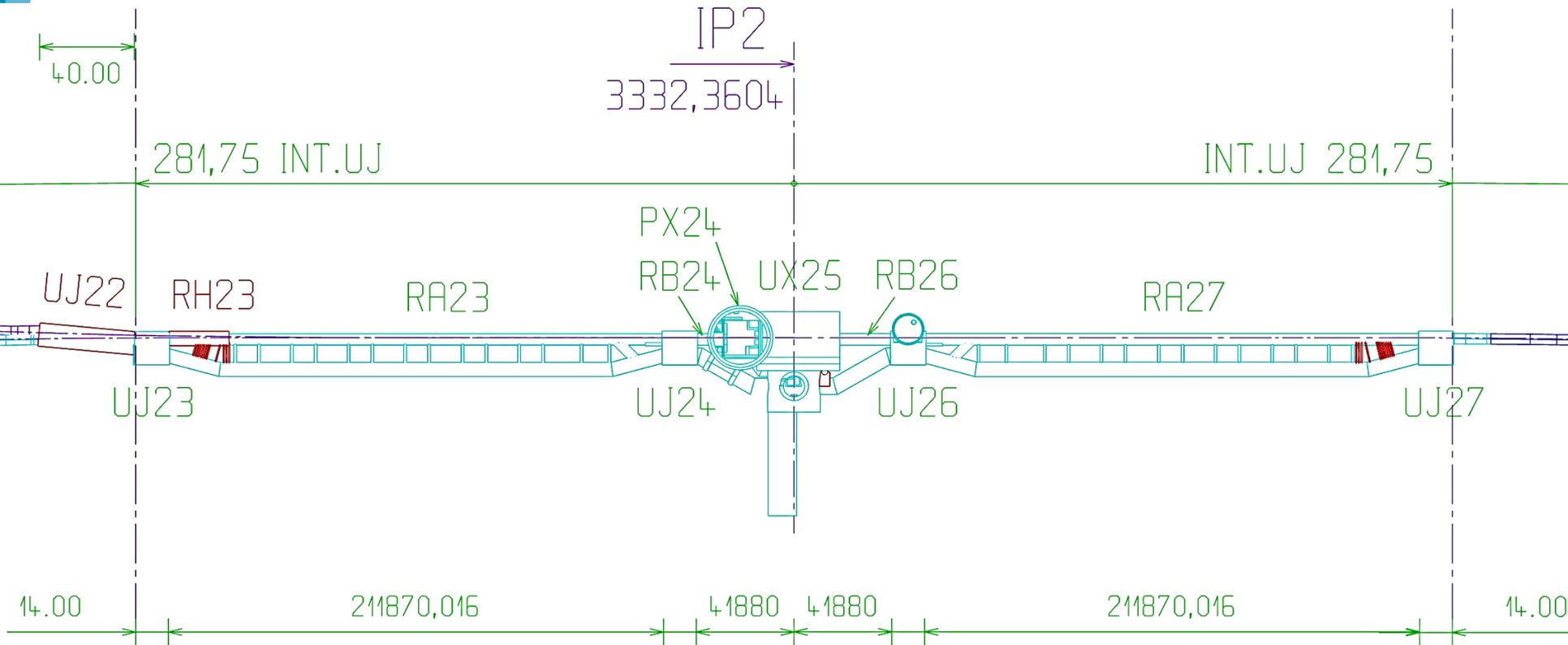


HL-LHC IR2 specifications: current status

- In summary, for IR2 the plan is the following (work in progress):
 - Shielded areas (and general overview of LSS levels): rescale Run 2 measurements with integrated luminosity for HL-LHC proton runs (need a reference value for the extrapolation). Additional contribution from TI2 injection line to be considered (as for IR8).
 - DS (up to the beginning of half-cell 11): use rescaled Run 2 BLM measurements from both proton and ion runs (probably dominated by ions, but proton contribution may be relevant in the first part of the DS).
 - DS (beyond half-cell 11): extract specifications from FLUKA simulation of TCLD losses (assuming radiation levels dominated by ions).

BACKUP

IR2 layout



layout provided by M.Mendes