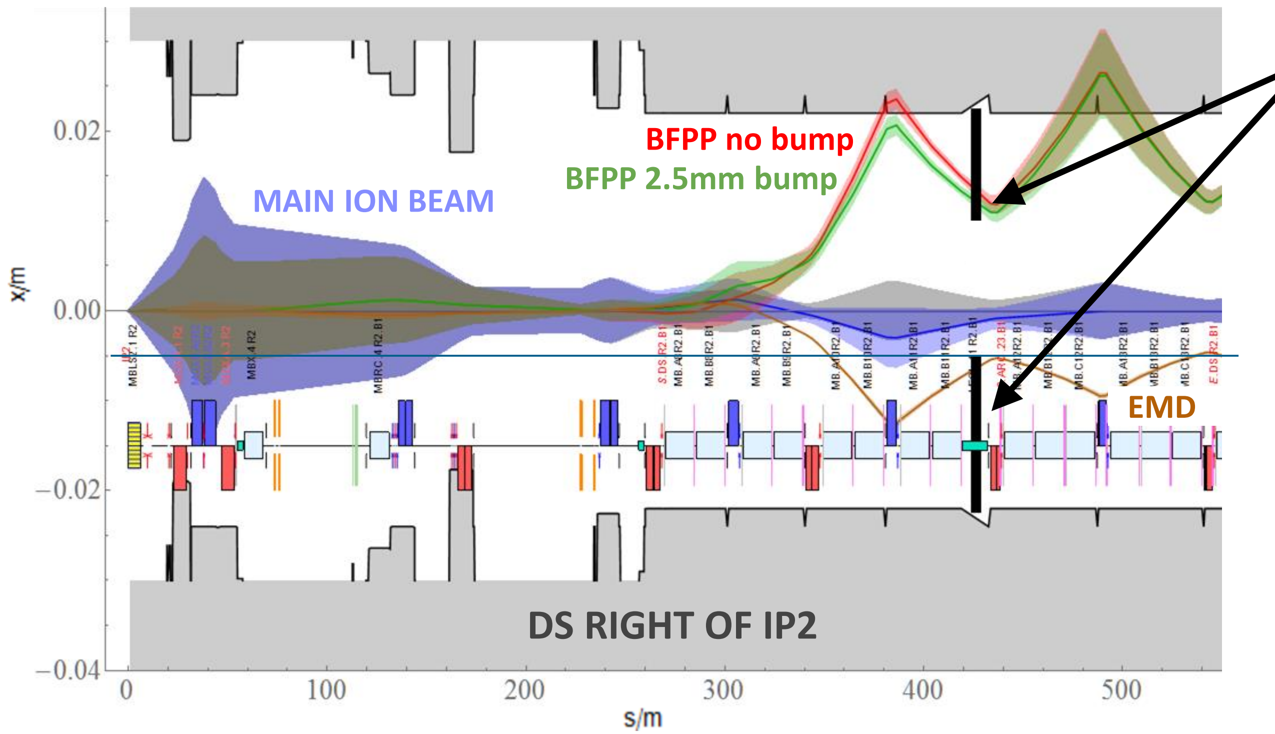
Needs for shielding in the connection cryostats in IR2 DS

Cristina Bahamonde, Anton Lechner with input from
M. Moretti, D. Duarte, A. Vande Craen,
T. Mertens, J.M. Jowett, R. Bruce, S. Redaelli, M. Schaumann,
M. Brugger, S. Danzeca, R. Garcia Alia

14th HL-LHC TCC
01/09/2016

Limiting case to evaluate the need for shielding: ion operation



J.M. Jowett, LHC Performance Workshop, Chamonix, 28/01/2016

TCLD.11R2 settings

60 cm tungsten jaws

Upper jaw 10.53 mm
Lower jaw -4.65 mm

Asymmetric setting to intercept BFPP and EMD with an impact parameter of 2 mm

Half gap ~30 sigma
(lower jaw)

T. Mertens

Other minor EM interactions could increase results ~10%

BFPP: $^{208}Pb^{82+} + {}^{208}Pb^{82+} \rightarrow {}^{208}Pb^{82+} + {}^{208}\mathbf{Pb}^{81+} + e^{+}$

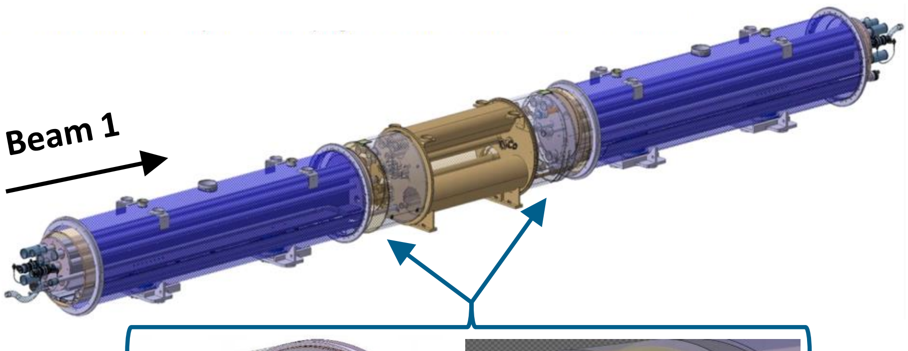
For HL-LHC conditions σ = 281 b, estimated beam power ~155W

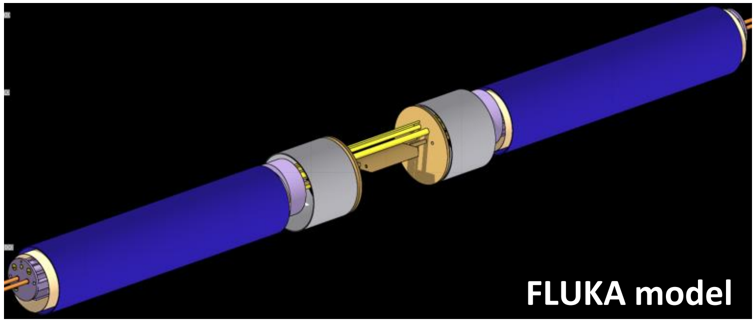
EMD: $^{208}Pb^{82+} + {}^{208}Pb^{82+} \rightarrow {}^{208}Pb^{82+} + {}^{207}\mathbf{Pb}^{82+} + n$

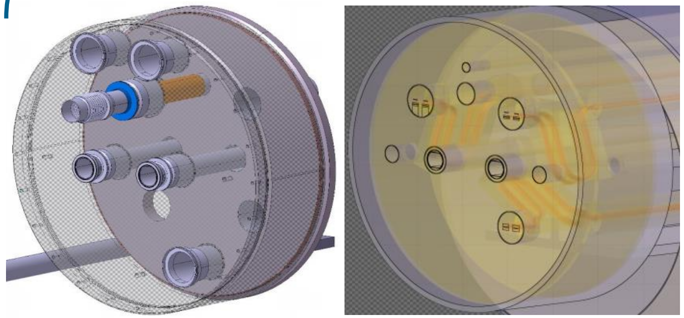
For HL-LHC conditions σ = 101.7 b, estimated beam power ~56W

Particle showers from TCLD intercepting these secondary beams could damage electronics or quench sensitive parts of magnets and bus bars further downstream

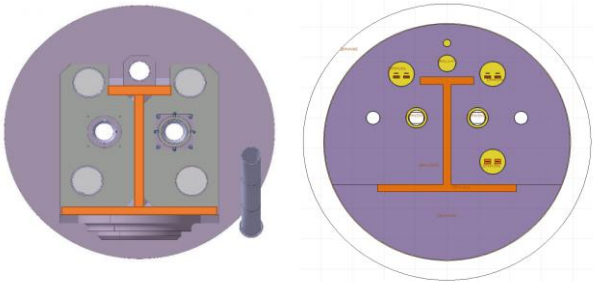
Implementation of the cryostat model in FLUKA



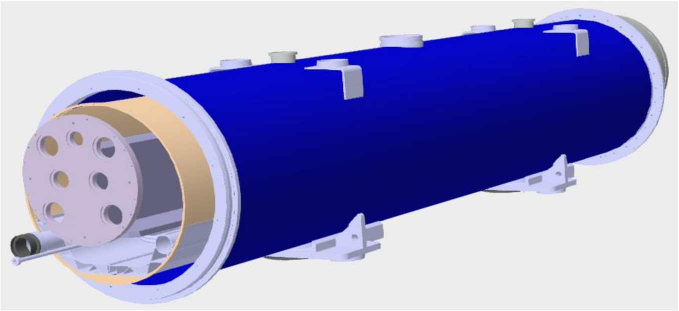


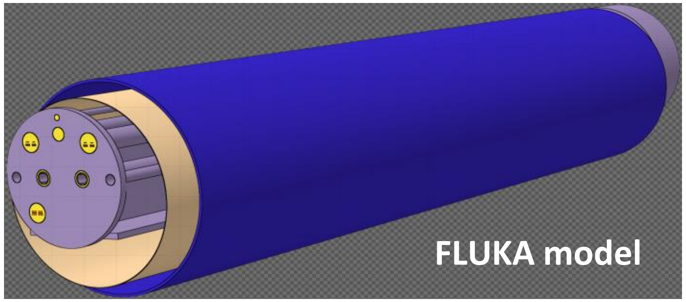


FLUKA model

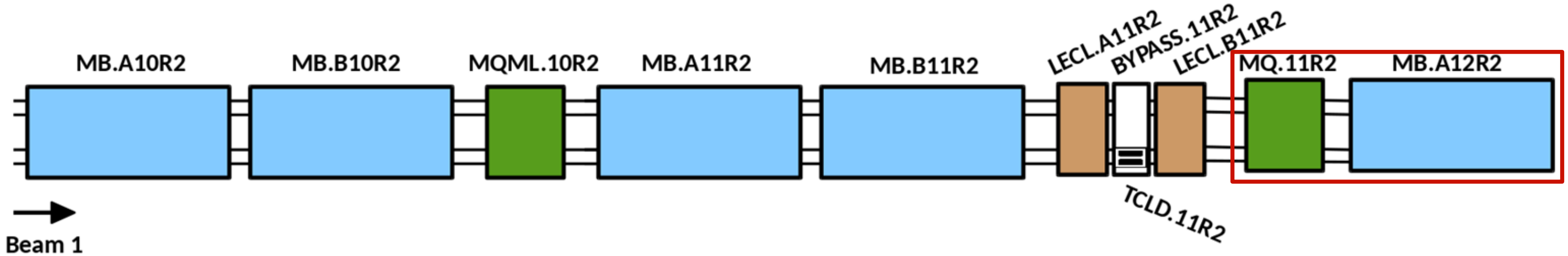


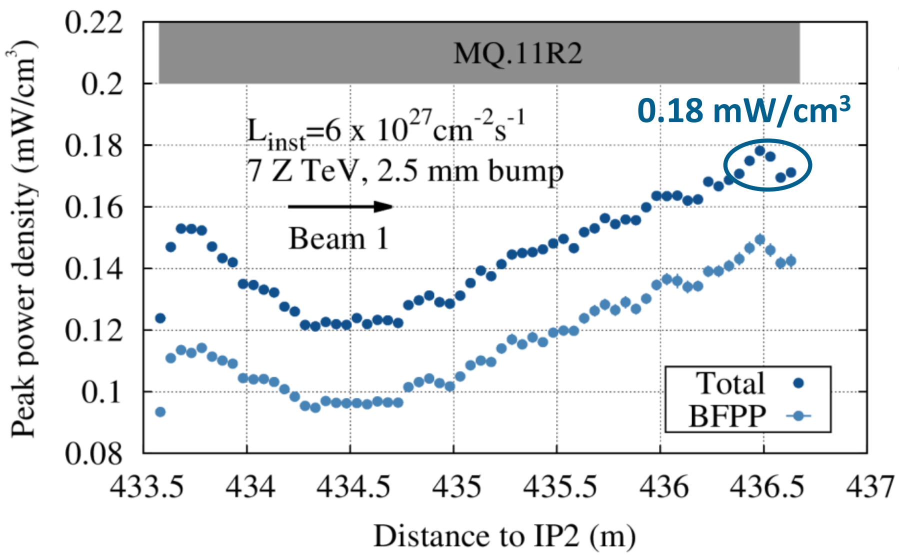
FLUKA model

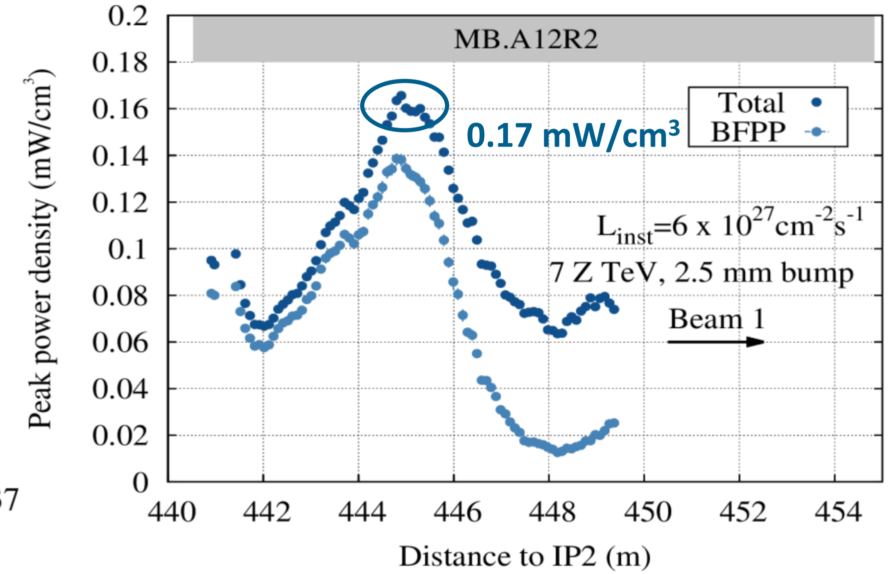




Quench risk: superconducting magnet coils

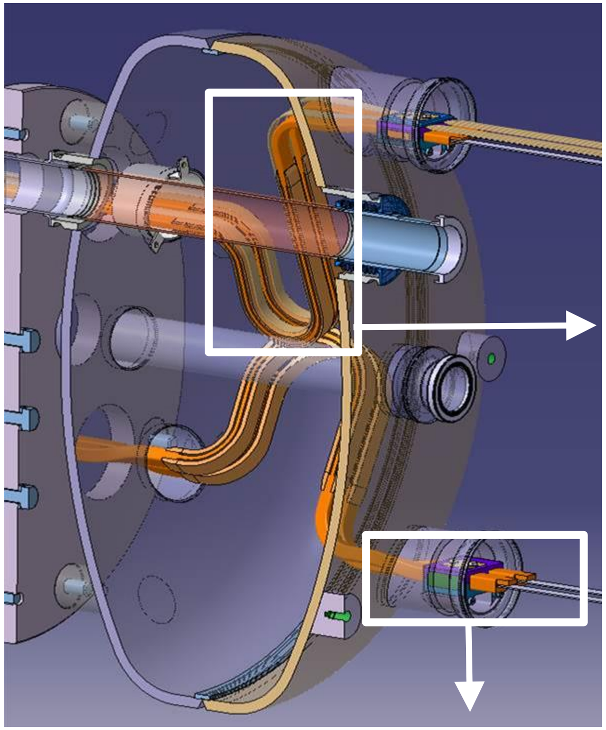




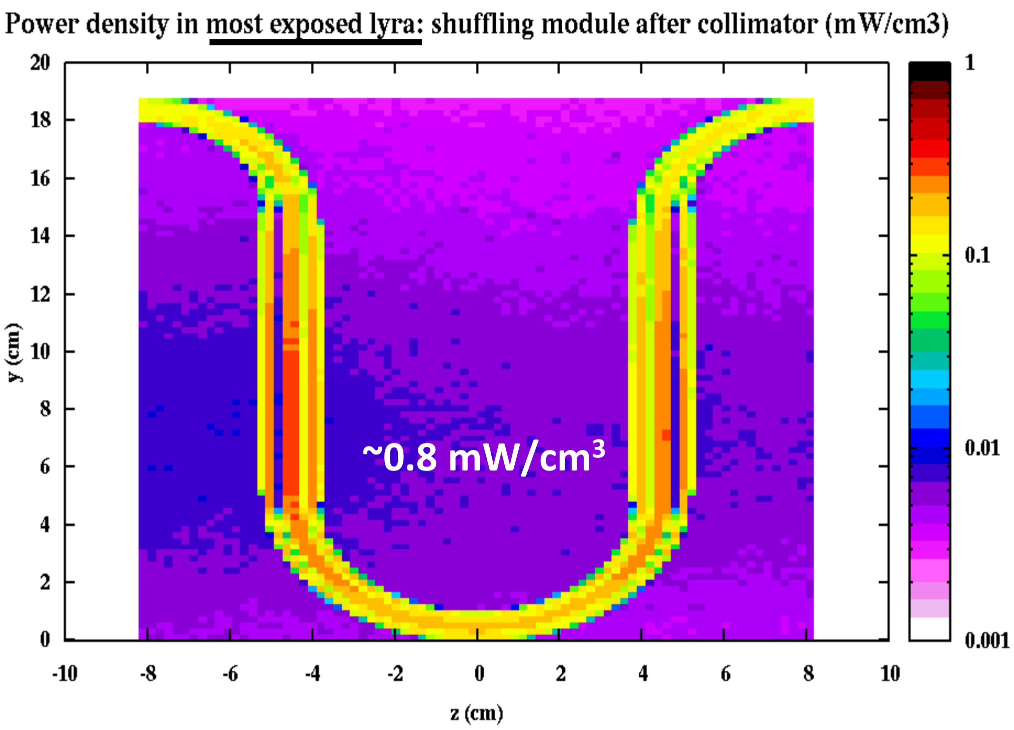


Collimator maintains the peak power density in the magnet coils at least a factor 10 below their estimated quench limit

Quench risk: lyras & M lines of the cryostat

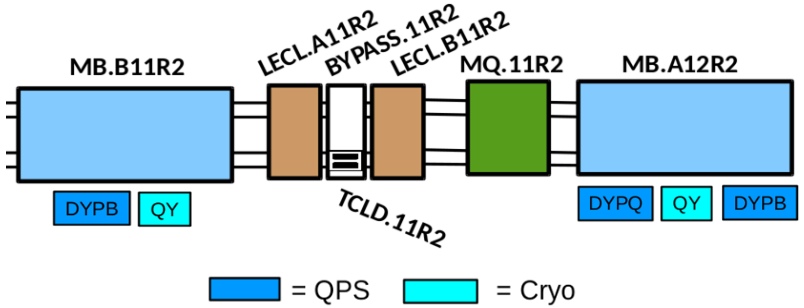


Most exposed M line ~2 mW/cm³



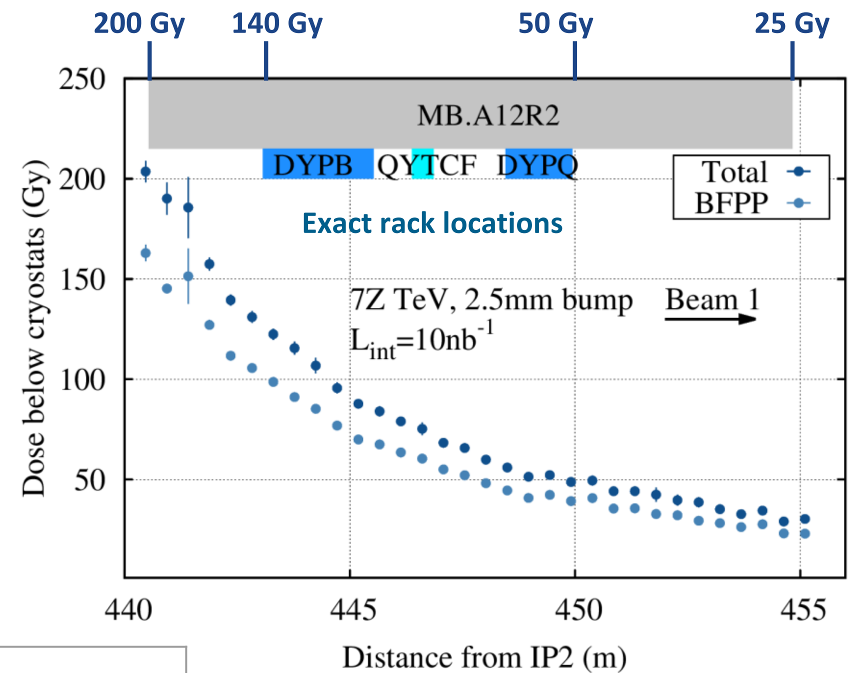
Current cryostat design with no added shielding gives a peak power density in the bus bars of at least a factor 100 lower than their estimated quench limit

Radiation to Electronics: cumulative damage (dose)



Results normalized to 10 nb^{-1}(target integrated luminosity for ALICE during the whole HL-LHC ion period)

Dose accumulated during ion runs over all years of HL-LHC operation



R2E expectations based on data for proton runs on IR1/5: target levels for electronics **per year**				
Cumulative damage to electronics	Run 3 (100 fb^{-1})		Run 4 (200 fb^{-1})	
	DS area (cell 7-11) Worst case	ARC area (cell 12-34)	DS area (cell 7-11) Worst case	ARC area (cell 12-34)
Dose	~40 Gy	~0.8 Gy	~80 Gy	~1.6Gy

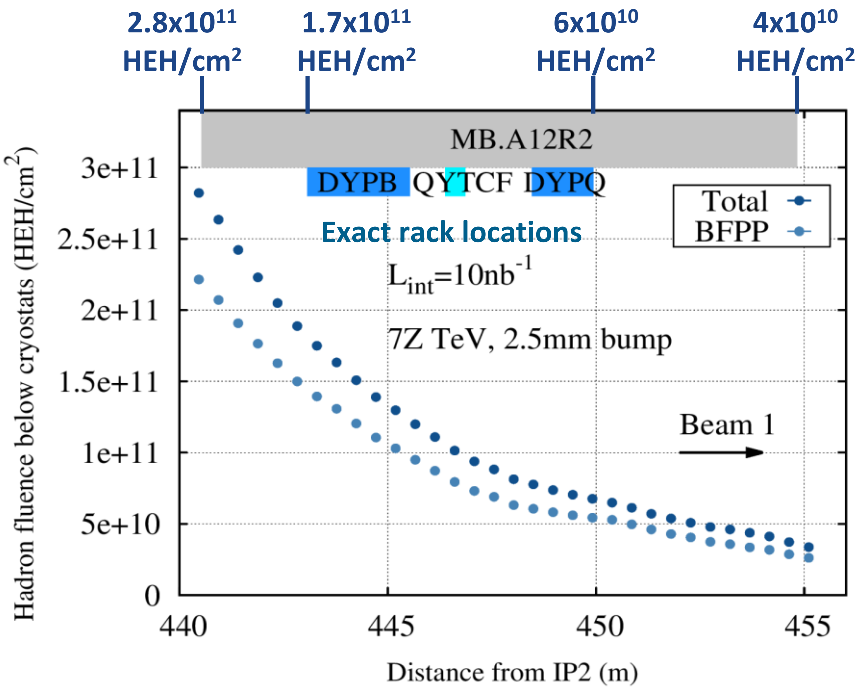
M. Brugger

Moving the electronic racks towards the end of the MB would halve the dose they are exposed to

For currently envisaged lifetimes <20 Gy/year or rack rotation *(M. Brugger)*

Rack rotation or non-electronic zone foreseen

Radiation to Electronics: Single Event Effects (HEH fluence)



Results normalized to 10 nb^{-1}(target integrated luminosity for ALICE during the whole HL-LHC ion period)

HEH fluence during ion runs over all years of HL-LHC operation

Probabilities of SEE failure for a certain HEH fluence are calculated for the total number of units in the machine

R2E expectations based on data for proton runs on IR1/5: target levels for electronics **per year**				
Single Event Effects (**stochastic**)	Run 3 (100 fb^{-1})		Run 4 (200 fb^{-1})	
	DS area (cell 7-11) Worst case	ARC area (cell 12-34)	DS area (cell 7-11) Worst case	ARC area (cell 12-34)
HEH fluence	~2×10^{10} HEH/cm^2	~4×10^{8} HEH/cm^2	~4×10^{10} HEH/cm^2	~8×10^{8} HEH/cm^2

M. Brugger

Probability of SEE failure may increase in these racks but not in the rest of the LHC areas: the overall probability of failure would not be significantly affected

No risk of compromising the machine operation due to HEH fluence levels

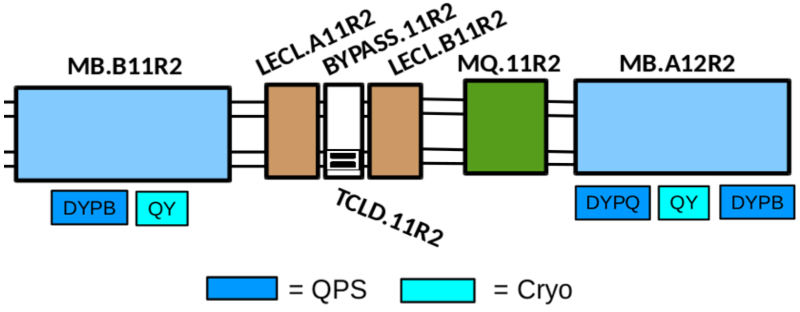
Conclusions and outlooks

For target instantaneous luminosities during ion operation ($6\times10^{27} cm^{-2}s^{-1}$), installing a collimator in the DS of IR2 (provided it intercepts the 2^{ary} beams with a 2mm impact parameter):

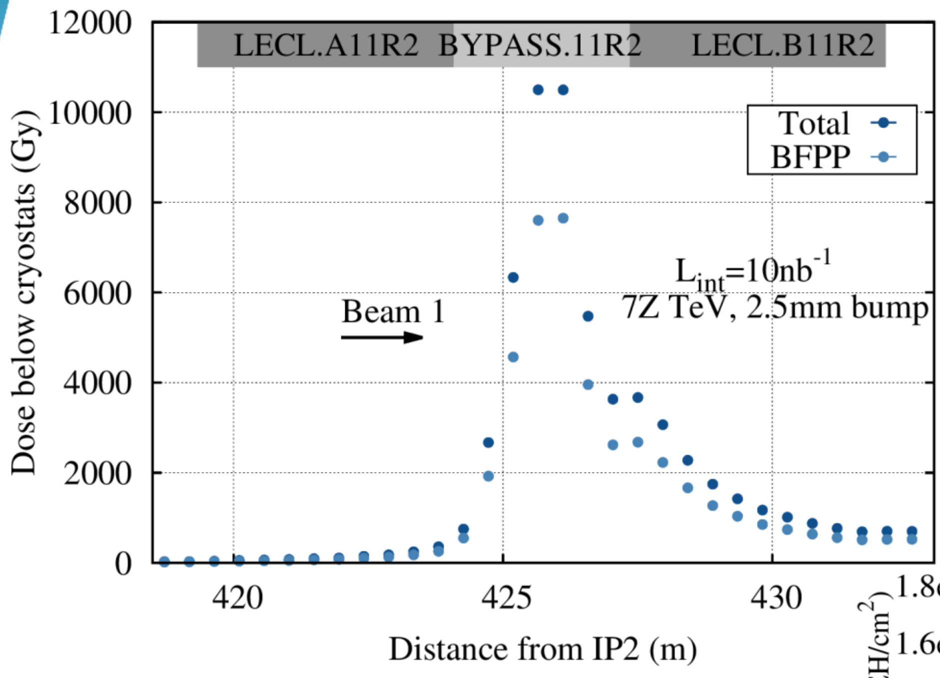
- eliminates the risk of quenching any downstream magnets
- does not introduce a risk of quenching M lines or lyras in the shuffling module

For a target integrated luminosity of 10 nb^{-1} over the whole HL-LHC ion operation, no added shielding in the new cryostat is required as long as:

- the electronic racks under the MB.A12 are displaced towards the end of the magnet. This way the dose they are exposed to would get halved
- a rack rotation or a non-electronic zone is foreseen

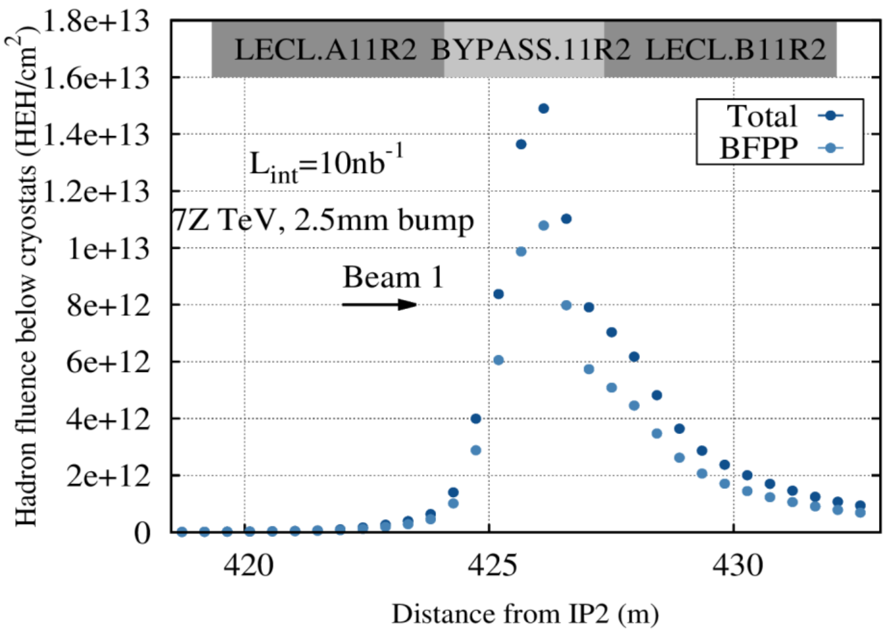


Radiation to Electronics: dose & HEH below new cryostats



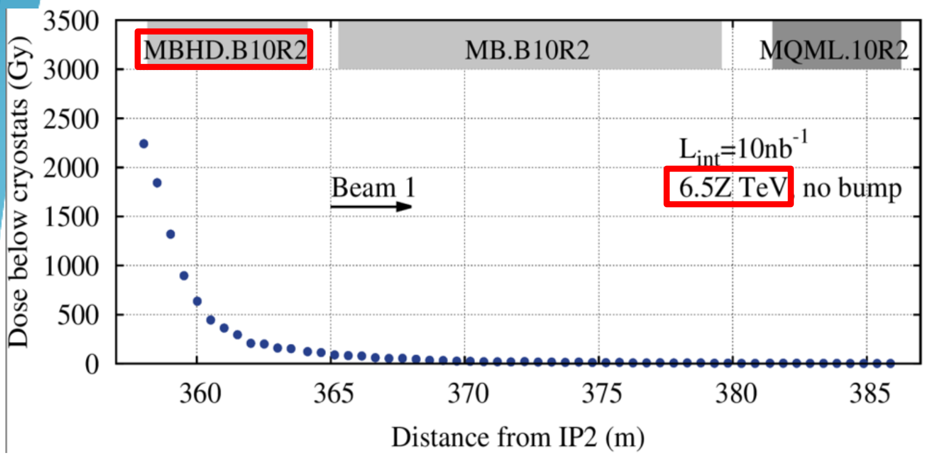
Results normalized to 10 nb^{-1}(target integrated luminosity for ALICE during **the whole HL-LHC ion period**)

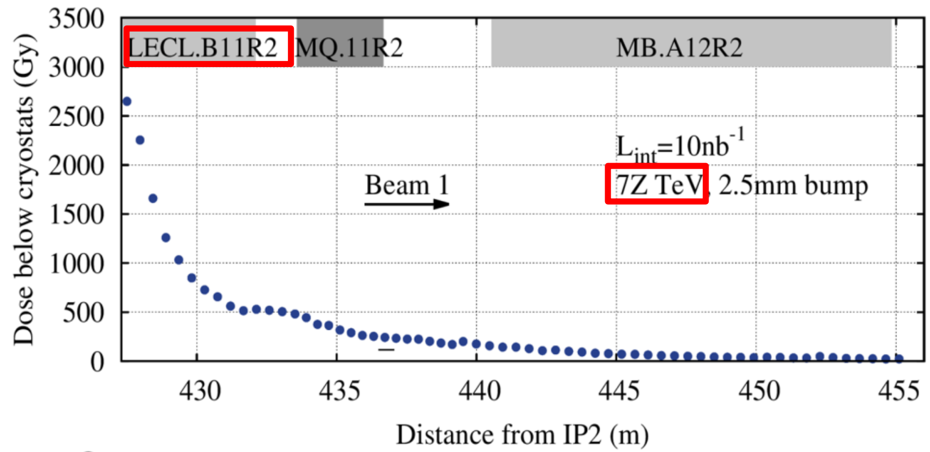
Dose and HEH fluence during ion runs over <u>all</u> years of HL-LHC operation

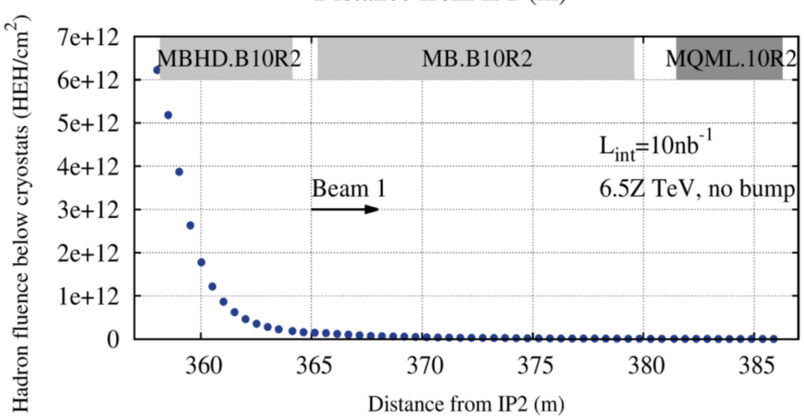


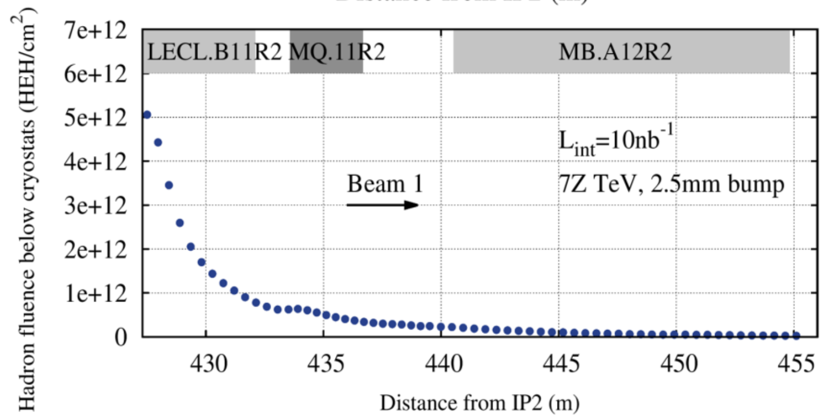
R2E: remark

BFPP contribution only









Dose and HEH fluence during ion runs over all years of HL-LHC operation