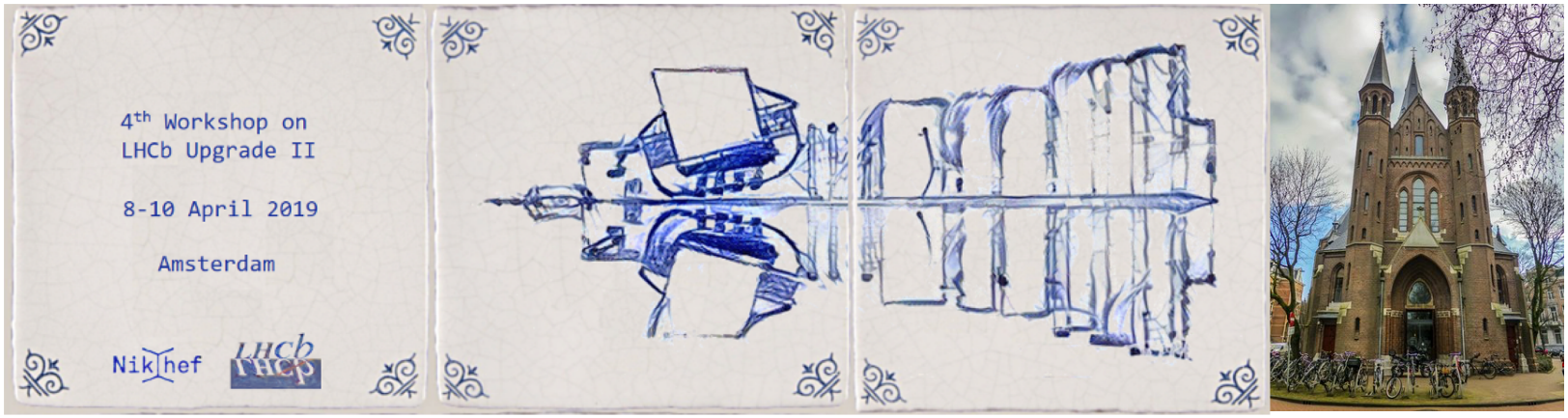


HL-LHC overview and plans for LHCb studies

Beniamino Di Girolamo (CERN ATS/DO)
On behalf of CERN Accelerator and Technology Sector

4th Workshop on LHCb Upgrade II – Amsterdam – 08-10 April 2019

CERN

Outline

- Preliminary work done so far
- Scope of further studies
- Organization to prepare a CDR/TDR for accelerator modifications
- Conclusions

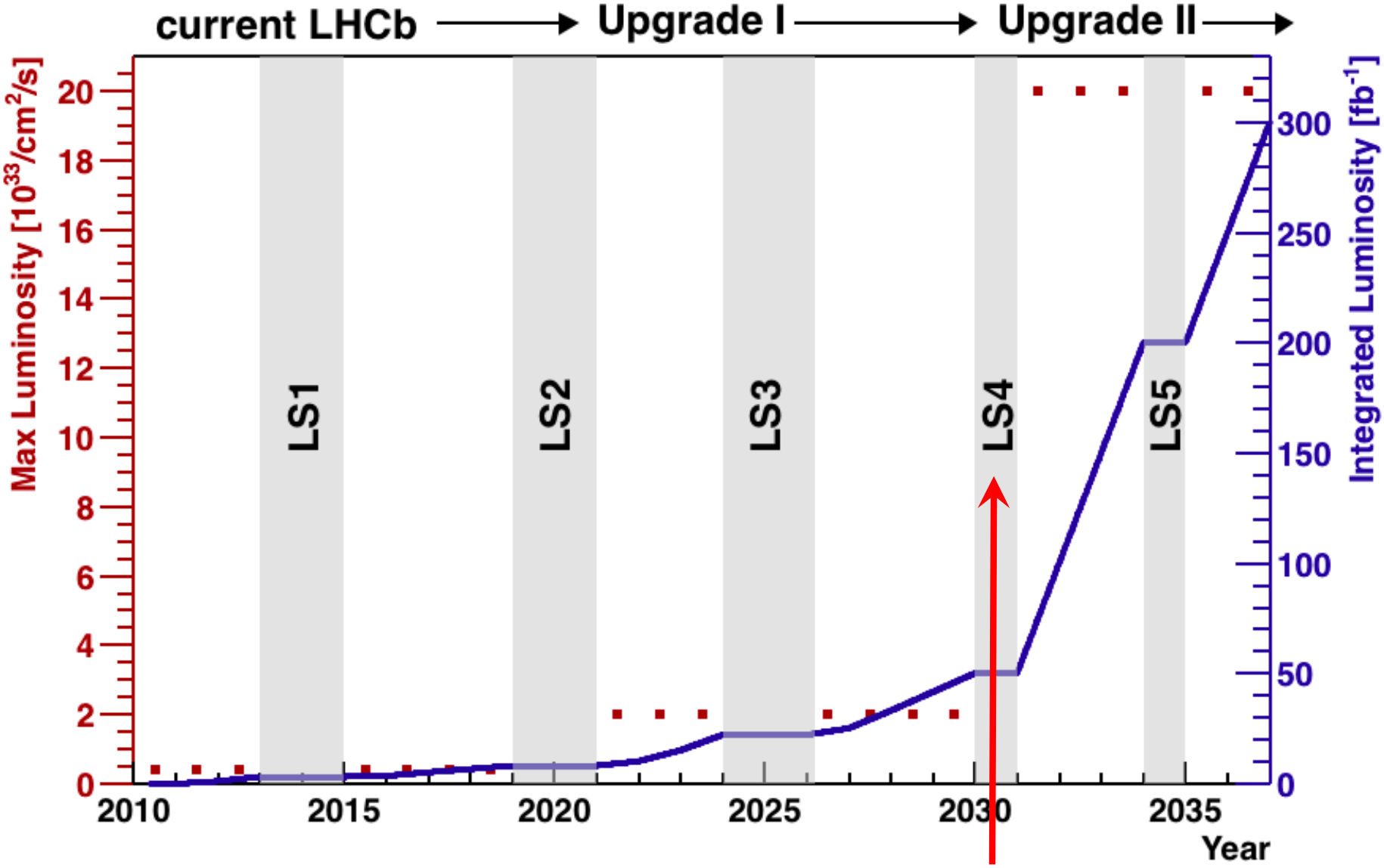
LHCb Upgrade II – operation at high luminosity

- Modifications to allow the experiment to collect 50 fb^{-1} every year if able to work at

$$\mathcal{L} = 1 \text{ to } 2 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$$

- Major ingredients :
  - adapting the beam optics, operation scenarios
  - increasing the protections for both LHC machine elements and detectors experimental cavern to the new environment
  - See Riccardo's presentation for the latest studies

LHCb - Luminosity upgrade summary



Optimistic/not realistic

Status of the studies in 2018

- Accelerator Note **CERN-ACC-NOTE-2018-0038** released
  - Overview of design studies and possible operational scenarios
  - Outline of issues to allow operations at high luminosity and possible mitigation solutions

- Full costing not yet completed
  - In the coming months a more detailed costing will be discussed with the CERN groups involved
  - Need to enter into details:
    - Update of energy deposition effects
    - Integration studies
    - Experimental areas aspects

CERN-ACC-NOTE-2018-0038

2018-08-29

Ilias.Efthymiopoulos@cern.ch

LHCb Upgrades and operation at 10^{34} cm^{-2} s^{-1} luminosity –A first study

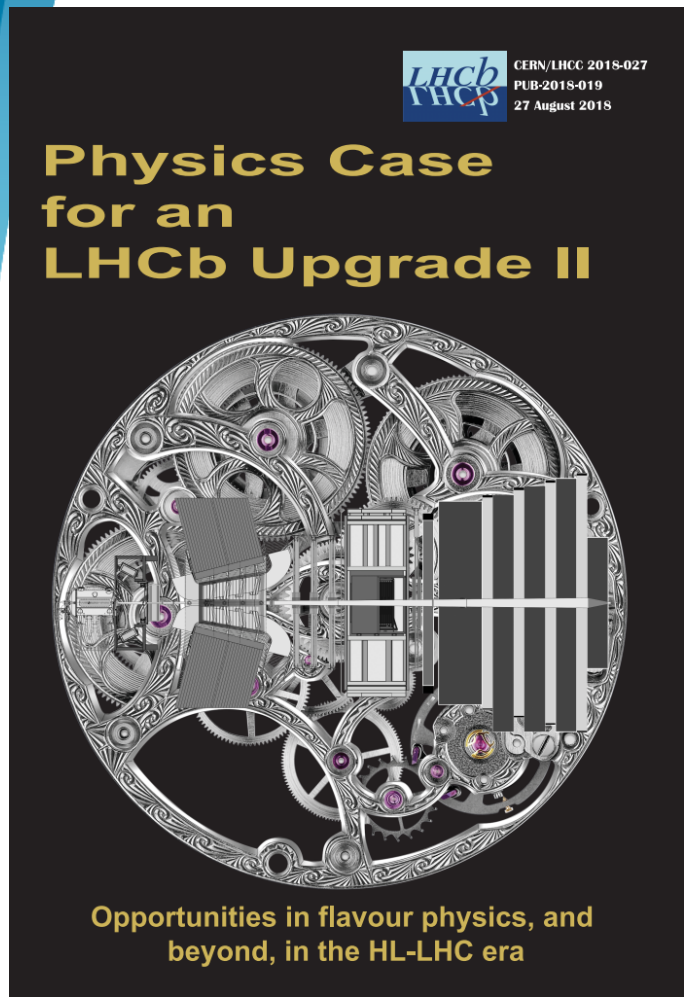
G. Arduini, V. Baglin, H. Burkhardt, F. Cerutti, S. Claudet, B. Di Girolamo, R. De Maria, I. Efthymiopoulos, L.S. Esposito, N. Karastathis, R. Lindner, Y. Papaphilippou, C.Parkes, D. Pellegrini, S. Redaelli, S. Roesler, F. Sanchez-Galan, P. Schwarz, E. Thomas, A. Tsinganis, D. Wollmann, G. Wilkinson
CERN, Geneva, Switzerland

Keywords: LHC, HL-LHC, HiLumi LHC, LHCb, https://indico.cern.ch/event/400665

Abstract

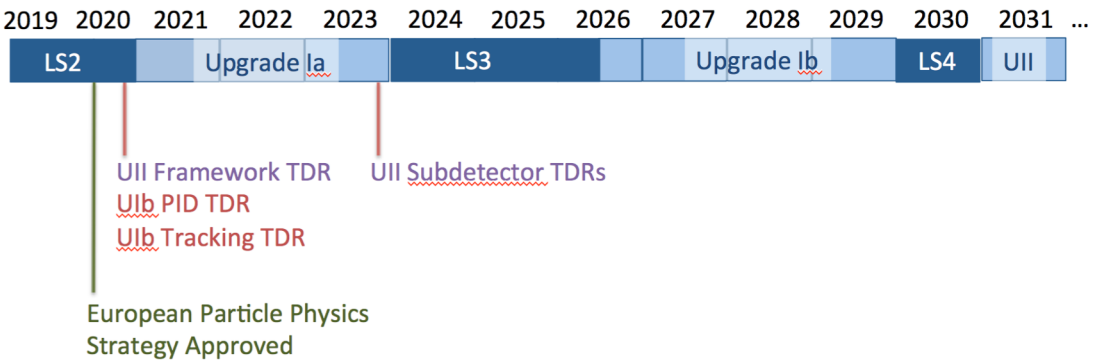
Presently, the LHCb experiment at IP8 operates at reduced luminosity (~4.0 10^{32} cm^{-2} s^{-1}) compared to ATLAS and CMS experiments. The LHCb collaboration is proposing an Upgrade II during HL-LHC operation, where the beams at IP8 will collide at high-luminosity (~1-2 10^{34} cm^{-2} s^{-1}), comparable to the present high-luminosity regions IP1&IP5. The LHCb experiment aims to collect more than 300 fb^{-1} by the end of the HL-LHC operation. A feasibility study of operating IP8 at high-luminosity whilst preserving the performance at IP1 and IP5 and on the impact to the LHC machine and experimental cavern was done. Optics studies shows that solutions allowing to reach an integrated luminosity of 40 to 50 fb^{-1} per year to LHCb/IP8 at the cost of a reduction of about 5% in the integrated luminosity of the main experiments ATLAS and CMS, under the assumption that there are no lifetime limitations besides burn-off, are feasible. Aspects like beam-beam effects that could have an impact on the beam lifetime and on the overall estimates of the integrated luminosities for LHCb and ATLAS and CMS need to be further studied. Energy deposition in the machine elements of the IR straight section 8 and LHC infrastructure and possible mitigation options were evaluated, revealing the challenges involved but also showing possible mitigation solutions. This is a first study with preliminary findings on the key aspects and a range of potential solutions for operating LHCb Upgrade II at a luminosity up to 2 10^{34} cm^{-2} s^{-1}, permitting the collection of 300 fb^{-1} or more at IP8 during the envisaged lifetime of the LHC. Further studies are needed to fully validate the proposed options.

LHCC session of Sept. 2018



LHCC minutes meeting:

"*The LHCC commends the LHCb collaboration for successfully preparing the physics case report for running beyond LS4 and supports the activities of the LHCb collaboration in planning for HL-LHC running through the* ***preparation of TDRs***"



From E. Thomas

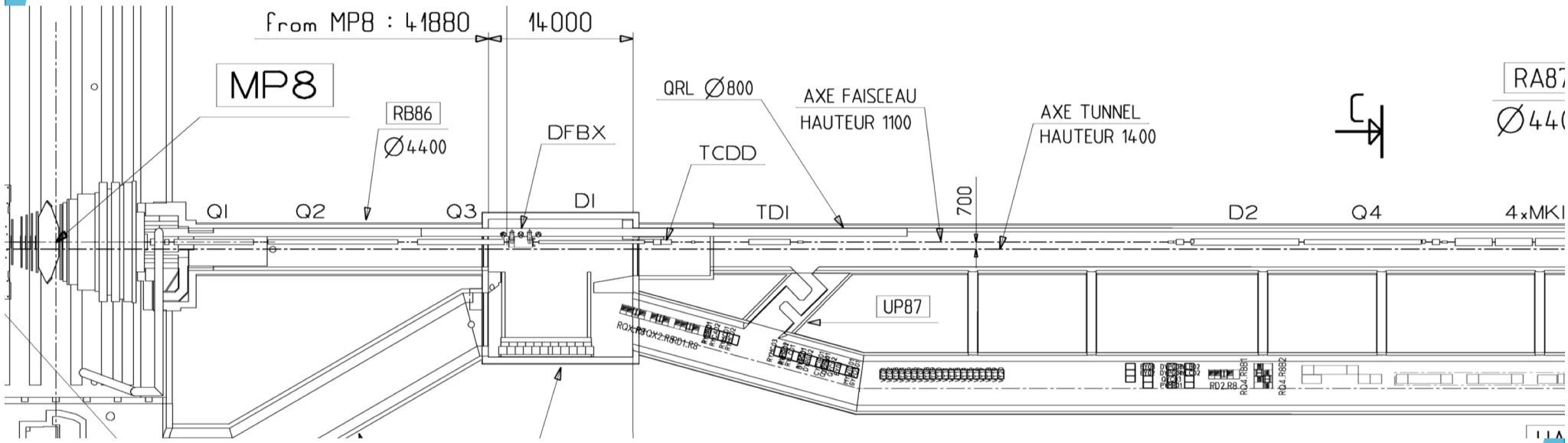
Challenges

- LHCb Upgrade II requires a number of modifications on the accelerator side
- The upgrade has been announced via the HL-LHC coordination meetings, a forum of experiments-accelerator interaction
  - A preliminary note has been prepared in 2018
  - It goes however beyond the HL-LHC project as it is focused to LS4
  - Need to proceed with a more detailed evaluation (CDR-like) to study feasibility and costs associated
  - Need of a dedicated forum

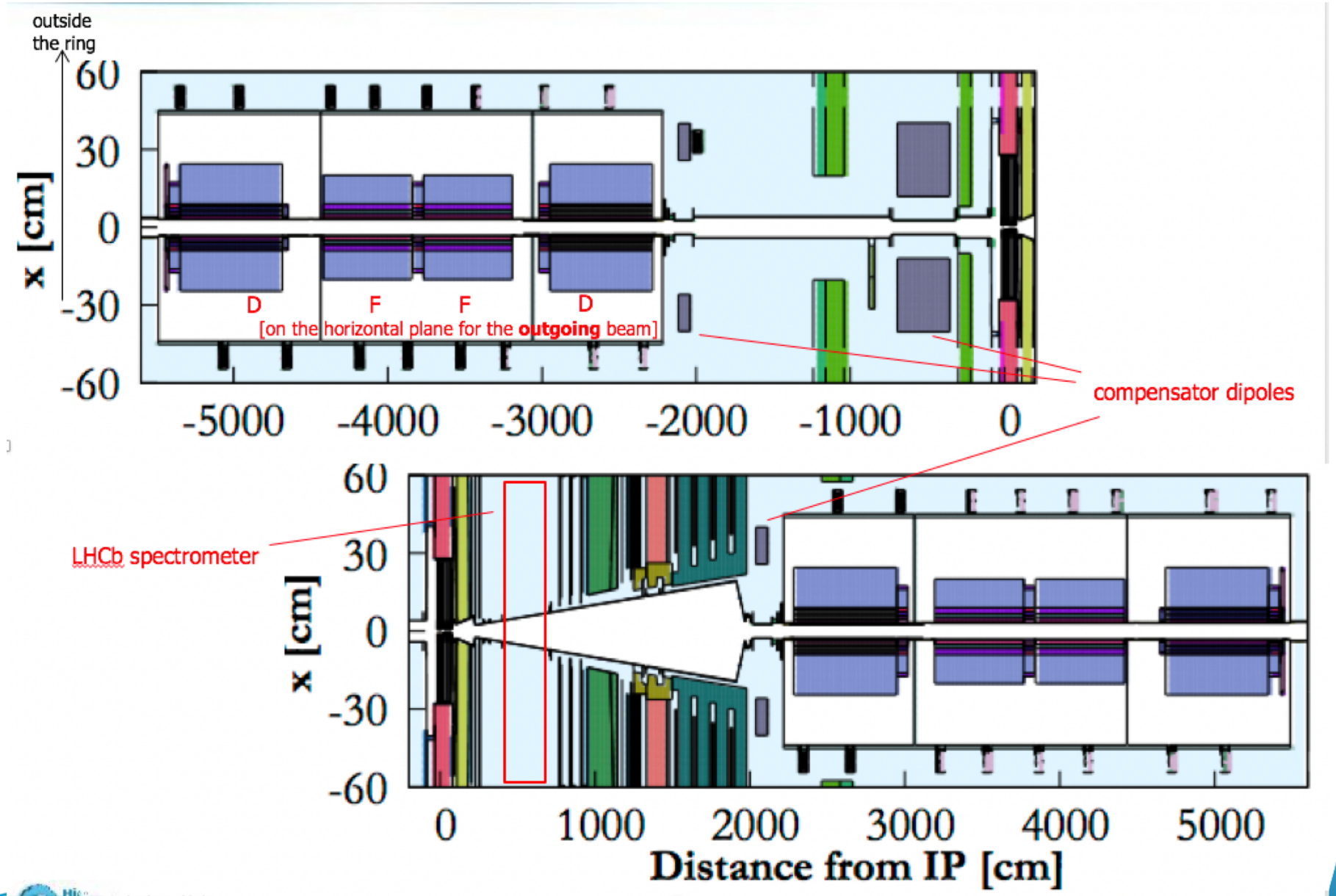
Constraints from the hardware side

- The preferred vertical crossing and the configuration of the beam screens, that cannot be changed without major disruption, is a challenge for beam operations (Riccardo has good ideas)
- The increase in heat load and in particle fluxes: the cryogenics dilemma
- The need of additional protections for magnets
- The reconfiguration of services, walls

Mapping to real hardware



Layout in Fluka



Energy Deposition Studies

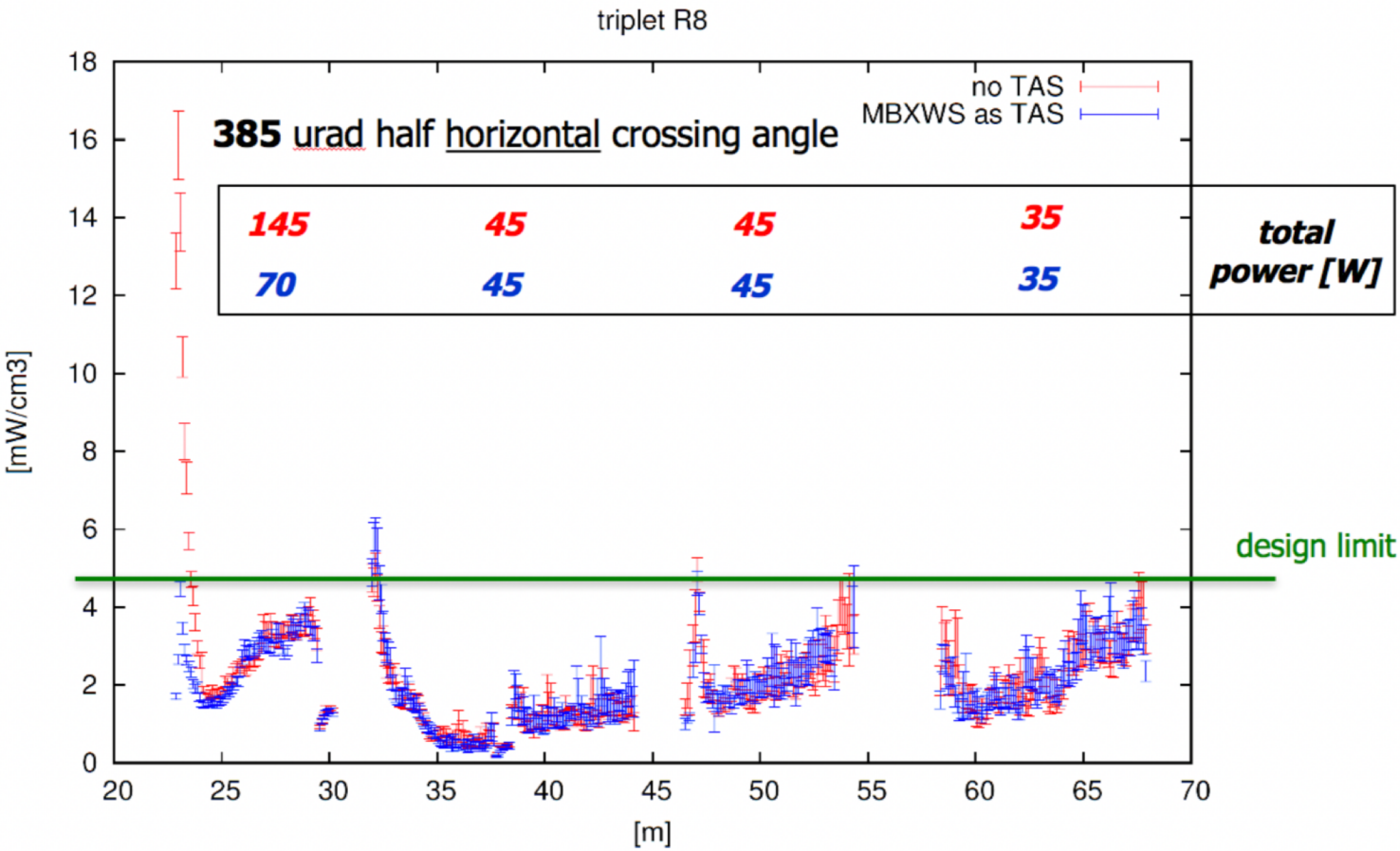
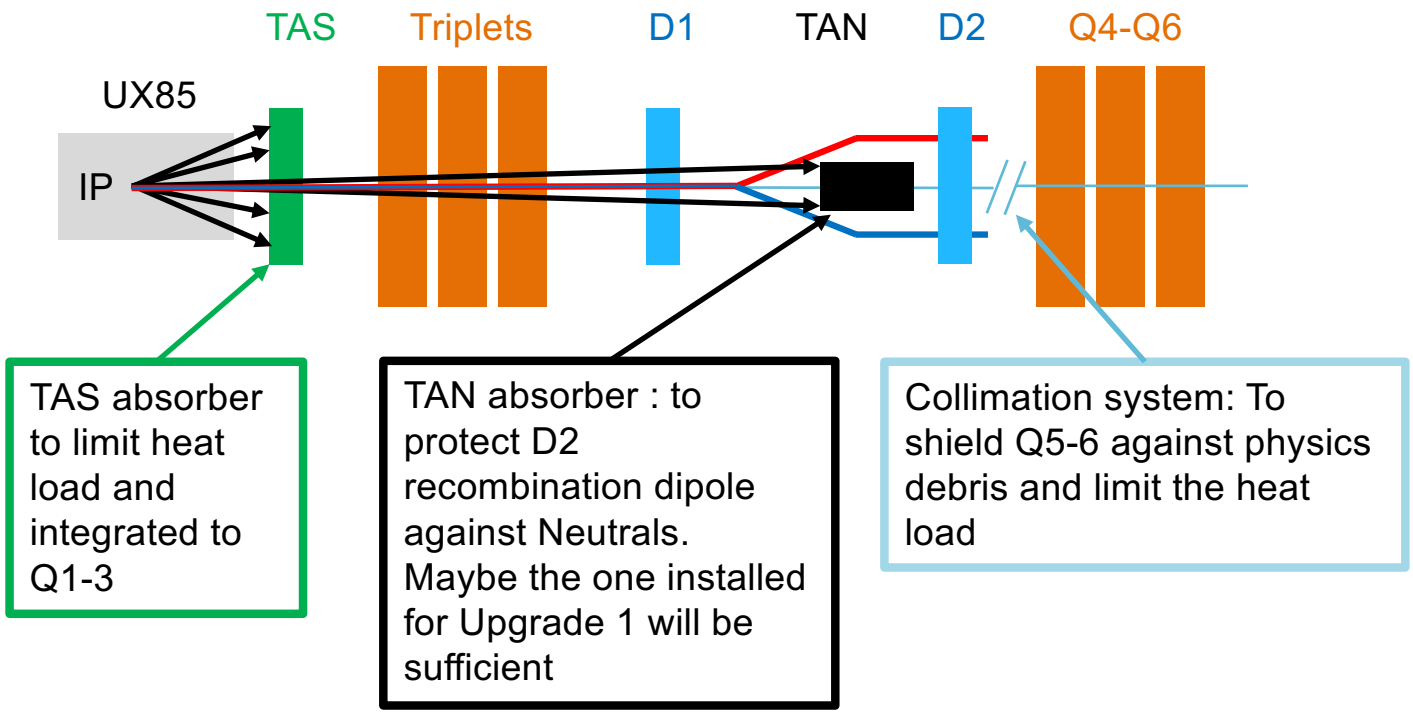


Figure 11 – Peak power density profile in the triplet and D1 superconducting coils on the right of IP8 for an instantaneous luminosity of 10^{34} cm^{-2} $s^{-1}$and a half crossing angle of 385 µrad at the collision point on the horizontal plane. Total power values in Q1, Q2, Q3 and D1 are also indicated. Vertical bars give the statistical error. Red points and numbers refer to the present layout, while blue ones refer to a case where the MBXWS integrates a tungsten absorber. The LHC design limit is shown.

LHCb @ High Lumi: Impact on HL-LHC Layout

CERN-ACC-NOTE-2018-0038



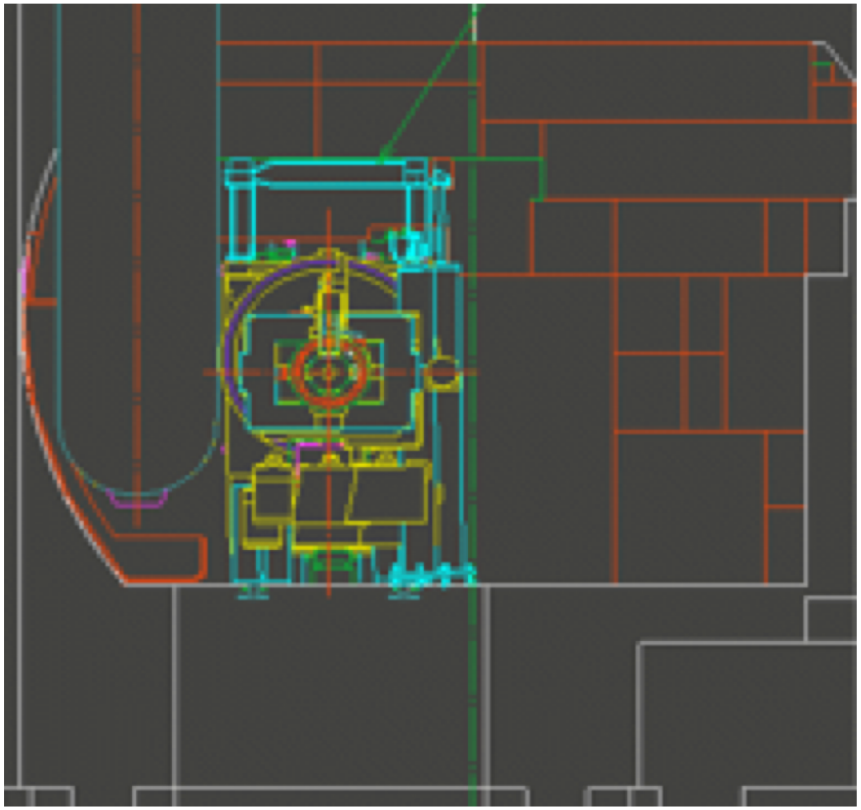
Also to be considered:

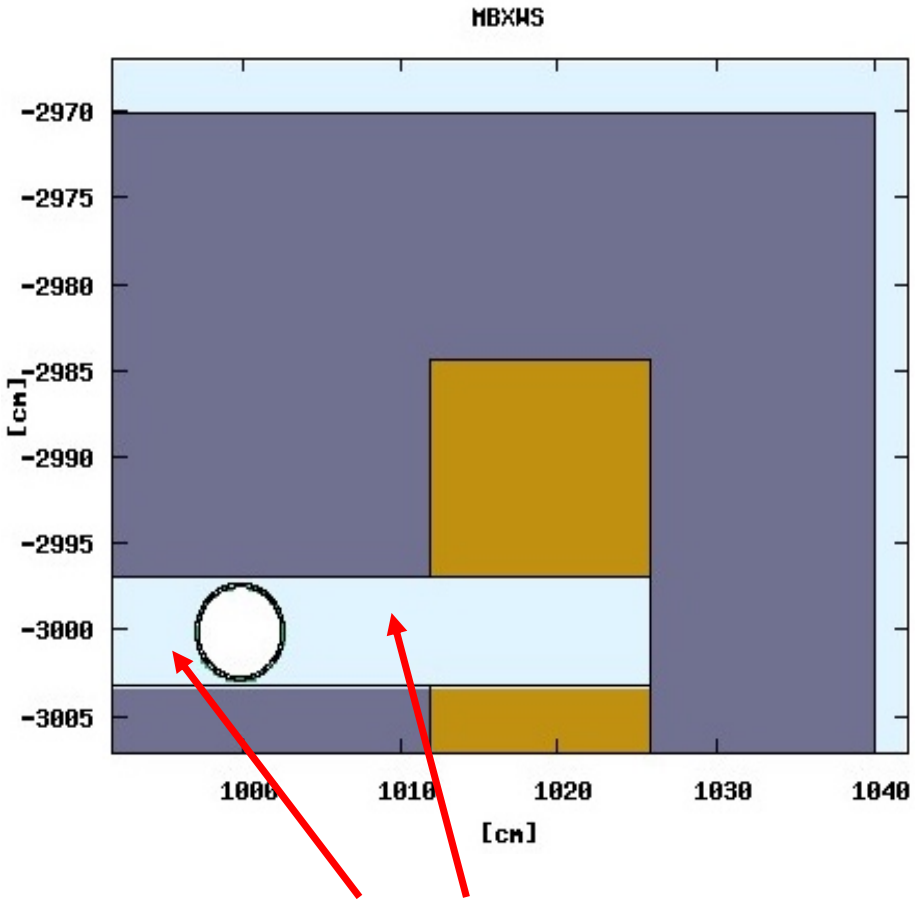
- Impact on Cryo infrastructure in UX/US85
- Impact on Cryo Lines
- Impact on Life time / exchange scenario of warm corrector magnet
- Impact General Infrastructure, Ventilation, Shieldings, R2E
- …

Energy deposition aspects

- Implementation of protections that haven't been considered before
  - A TAS-like based on filling with tungsten bars the MBXWS magnets or normal TAS
  - Possibly a longer TAN than currently planned to be installed during LS2 for Upgrade I, to be studied
  - Prolongation of the shielding to Q1-Q2 interconnect (a reinforcement as in HL-LHC)
  - TCL collimators for Q5 protection
  - Better definition of the TCDDM mask in front of the D1 magnet
  - Issues in Q4 observed at IP1 and IP5: under study

TAS-like MBXWS





To be filled with tungsten bars

Energy deposition aspects

- Magnets ageing or robustness
  - Inner Triplets should be ok up to 300 fb^{-1}
    - Exchanged magnets from IR1 and IR5 could be considered as spares, although second hand and having got 300 fb^{-1} or more
  - There is a need of more investigations on the D1 magnets
    - If new magnets have to be built this would have a clear cost impact
  - The ageing and servicing of the “instrumented” MBXWS have to be assessed
    - Spare magnet for fast exchange, 75 MGy dose after 250 fb^{-1}
- Power converters might be updated, being studied

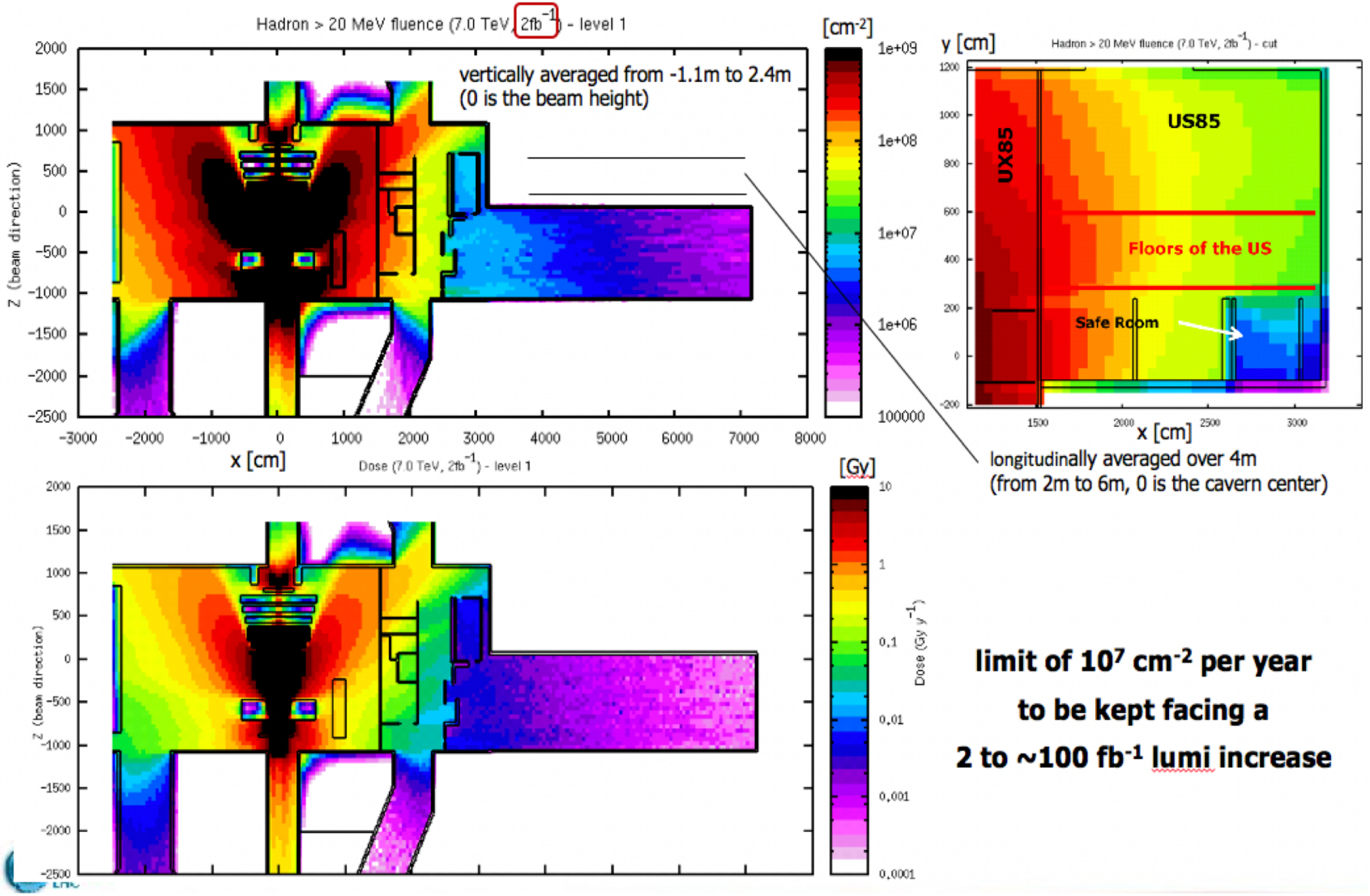
Impact on cryogenics

- Heat load and cooling requirements
  - Need of more input for energy deposition in coils (tolerance to quench) and for power for cold mass and beam screens (capacity of local cooling loops)
  - First estimates for global cooling capacity for R8 and sector 81 is favorable thanks to HL-LHC upgrade at P1
  - More delicate for L8 and sector 78 if impacted
- Interference with cryogenics equipment, QRL or boxes
  - Input on QRL zone to be relocated, keeping boxes and equipment in place
  - Input on zones of cryo boxes impacted if any

Impact on cryogenics

- Availability/reliability w.r.t. radiation doses, fluence and magnetic field
  - Additional radiation and neutron fluences requires the evaluation of the situation for UX85 and US85 cryogenic instrumentation, electronics and control equipment
    - Need of input on radiation dose map and fluence
    - Proposed shielding (material and thickness) for COTS electronics
    - Stray field (tolerance of cold compressors active magnetic bearings)
  - Adequate shielding to keep boxes and equipment in place has to be the first thing to investigate, otherwise high costs from Civil Engineering

Hadron fluences and doses



limit of 10^7 cm^{-2} per year

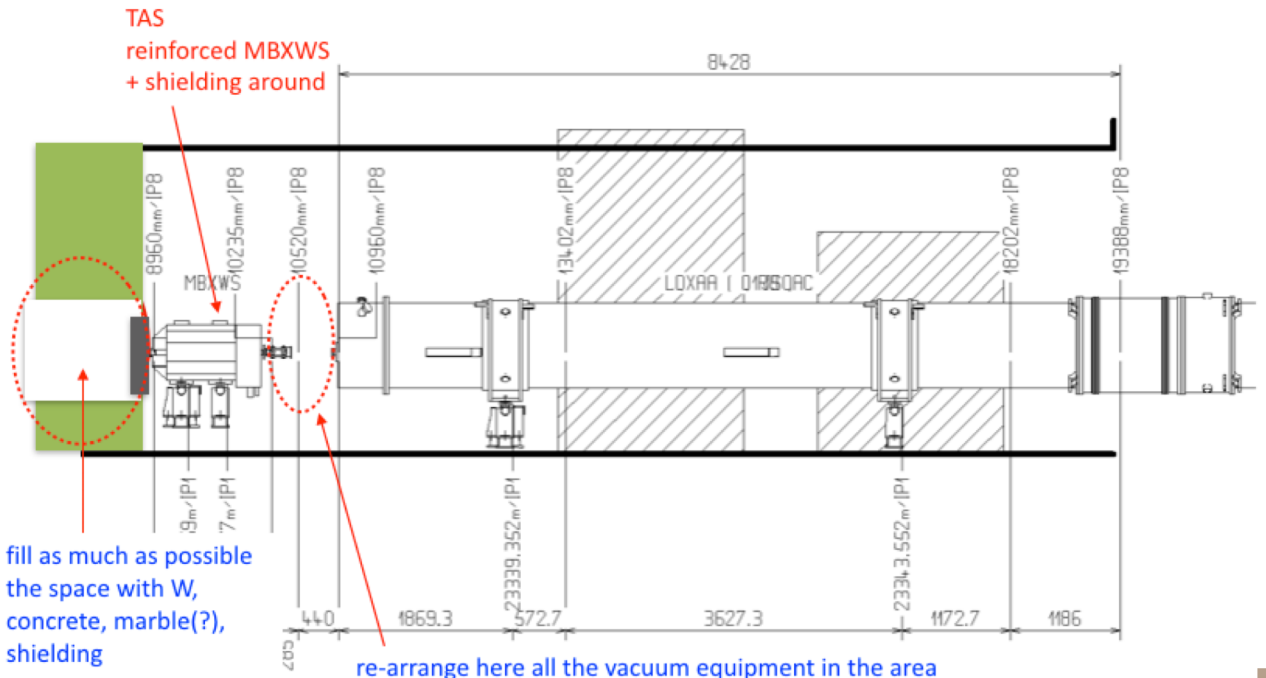
to be kept facing a

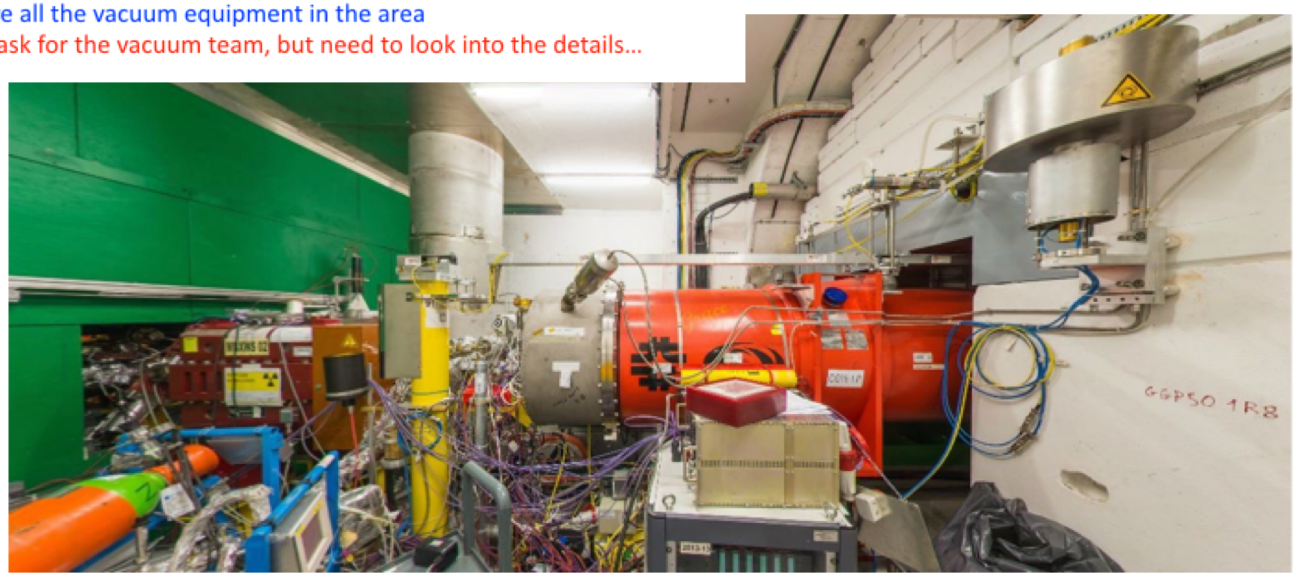
2 to ~100 fb^{-1} lumi increase

Other aspects

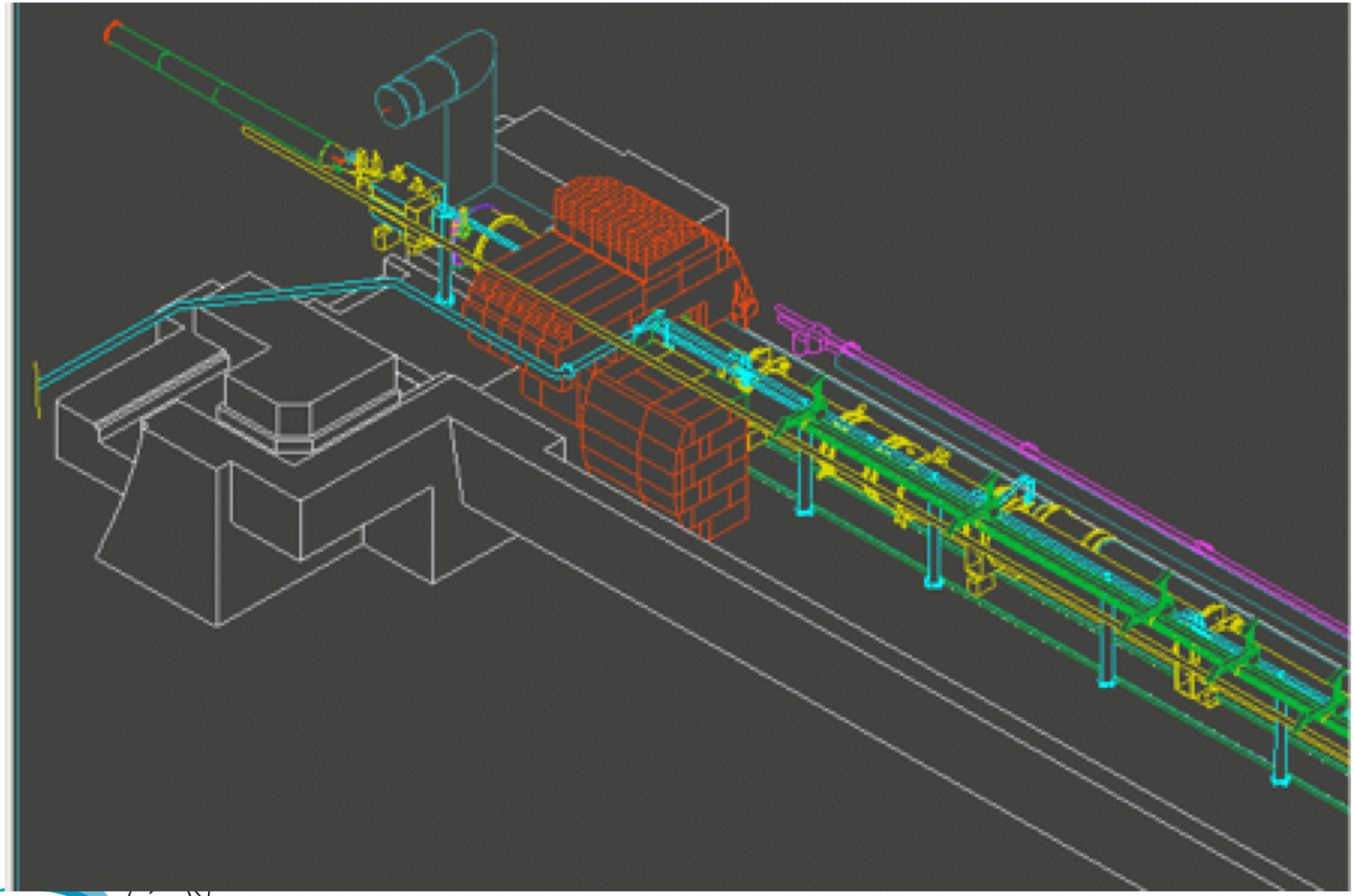
- Impact on ventilation system, other R2E needs, integration aspects for the additional protections and collimators
- Vacuum equipment displacement from hot regions around TAS-like for ALARA reasons
- Powering and machine protection aspects under consideration
- Modifications to services, walls etc. see next slides

Modifications RB86



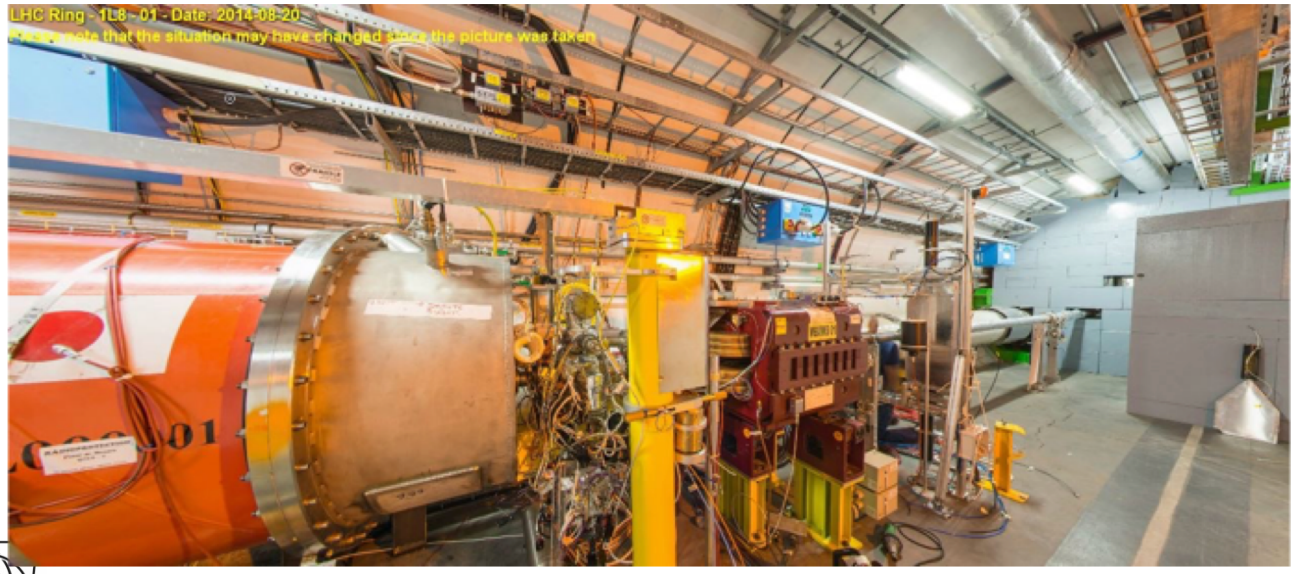


Modifications RB86



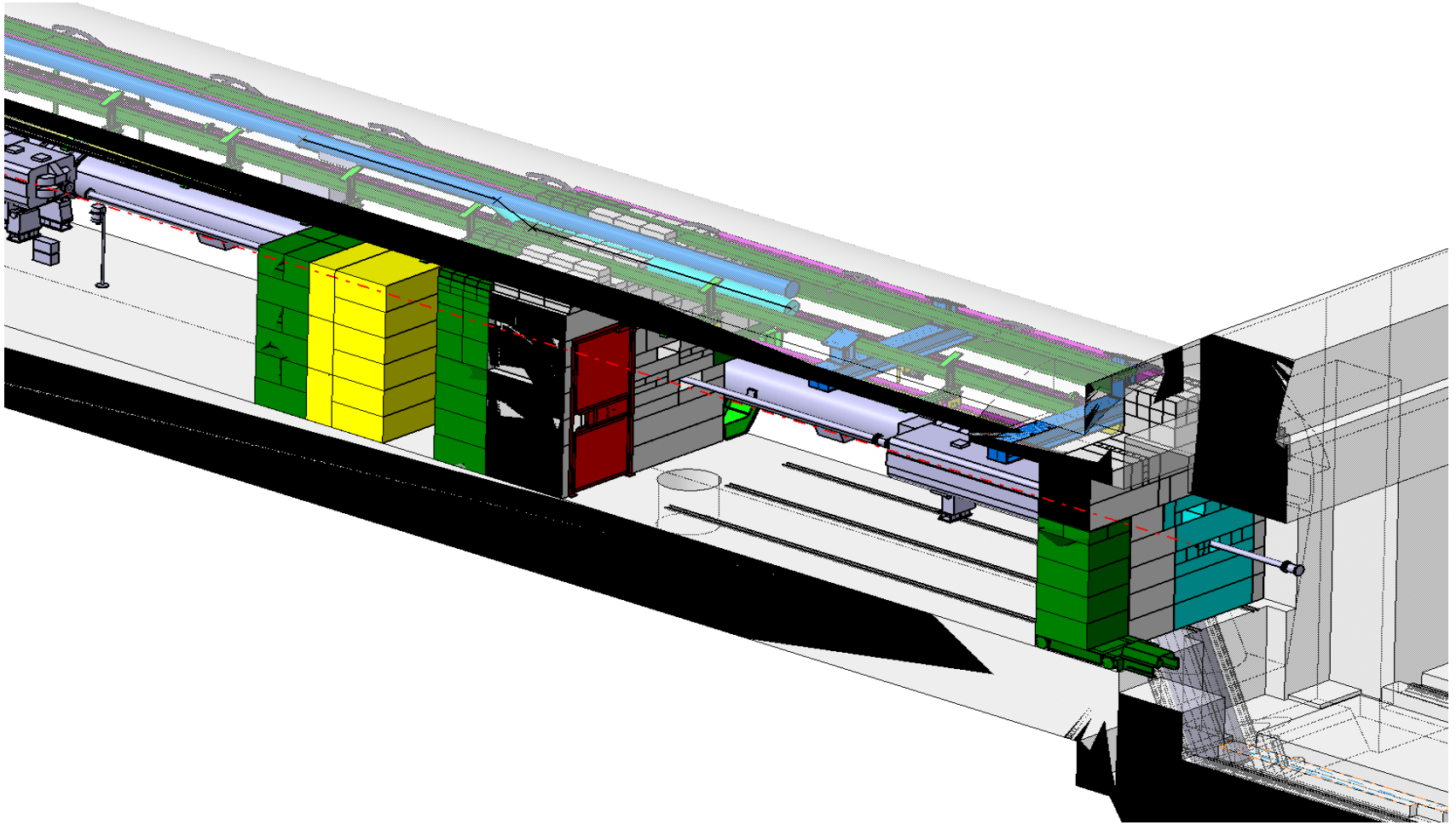
Modifications RB84

Wall to be reinforced



Services to be rearranged: easier than on the RB86 side

Modifications RB84



How to proceed in future

- Timescale for LHCb Framework TDR production is from now to Fall 2020
- We need to ensure we follow the process and we interact and we aim at producing a CDR-like documenting feasibility and cost on the same timescale
- We need to have a proper lightweight structure on the accelerator side and some meetings with the participation of the experiment contact person
- No surprises on both sides
- We need some small budget for studies

Proposed lightweight structure

- It is a (small) project that comes in LS2
- Each group involved (in TE, EN and BE) appoints a contact person
  - To look at issues and solutions
  - To evaluate the costs
- Interactions via e-mail and topical (1:1 or so) short meetings (once a month in 2019). No agenda no meeting. Minutes
- More populated, but less frequent, meetings for inter-dependencies (once every two months in 2019). No agenda no meeting. Minutes
- Two meetings of interaction with experiment in 2019 (May and October)
- Possible increase of frequency when approaching September 2020 (that means April 2020 for circulating drafts)
  - If timeline doesn't change

Conclusions

- Focusing now to studies to have a more precise costing
- This work comes in LS2 where a lot of key players have high load
  - Light project structure to limit impact whilst producing suitable documentation
- The cryogenics boxes shielding has to be seriously considered to limit costs
- We will define costs in a conservative way to avoid later surprises
- I am your point of contact in the A&T Sector for this Upgrade

Thanks

A lot of people have contributed to the accelerator note and beyond and to whom goes my gratitude

Many thanks to LHCb for the invitation and the wonderful location and interesting workshop