Post-LS3/4(?) Operation of LHCb @ LHC Nominal Luminosity (1-2 10^{34} cm^{-2} s^{-1})

Hardware aspects

Implications on existing, and needed new hardware

first look!

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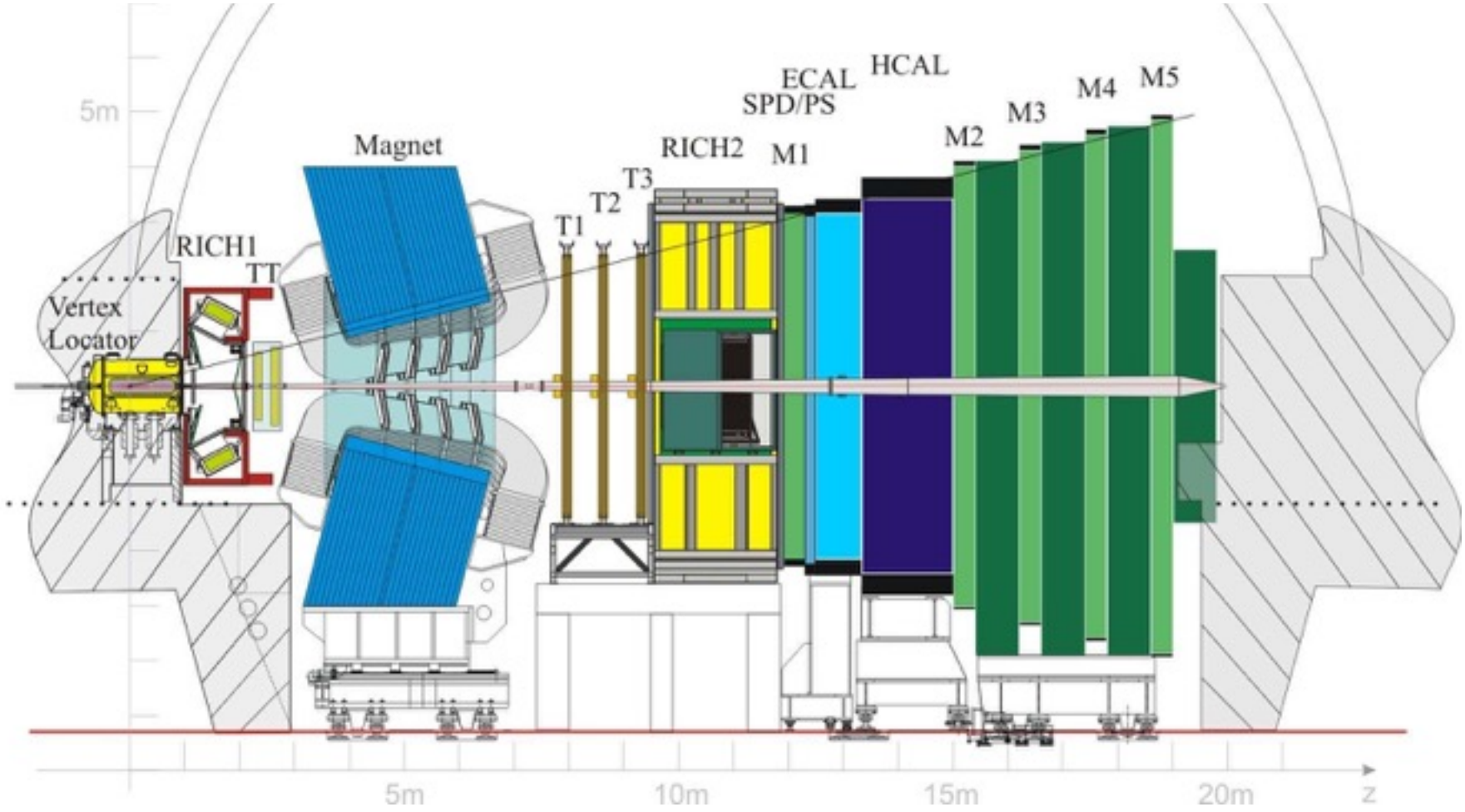
LHCb operation @ LHC nominal luminosity

- Start with the most challenging option where the IP position is shifted wrt the present by **3.75 m**
  - preferred layout from the experiment - maximise physics reach
  - depending on the findings, we'll go back to the experiment and propose alternative layouts with compromises…

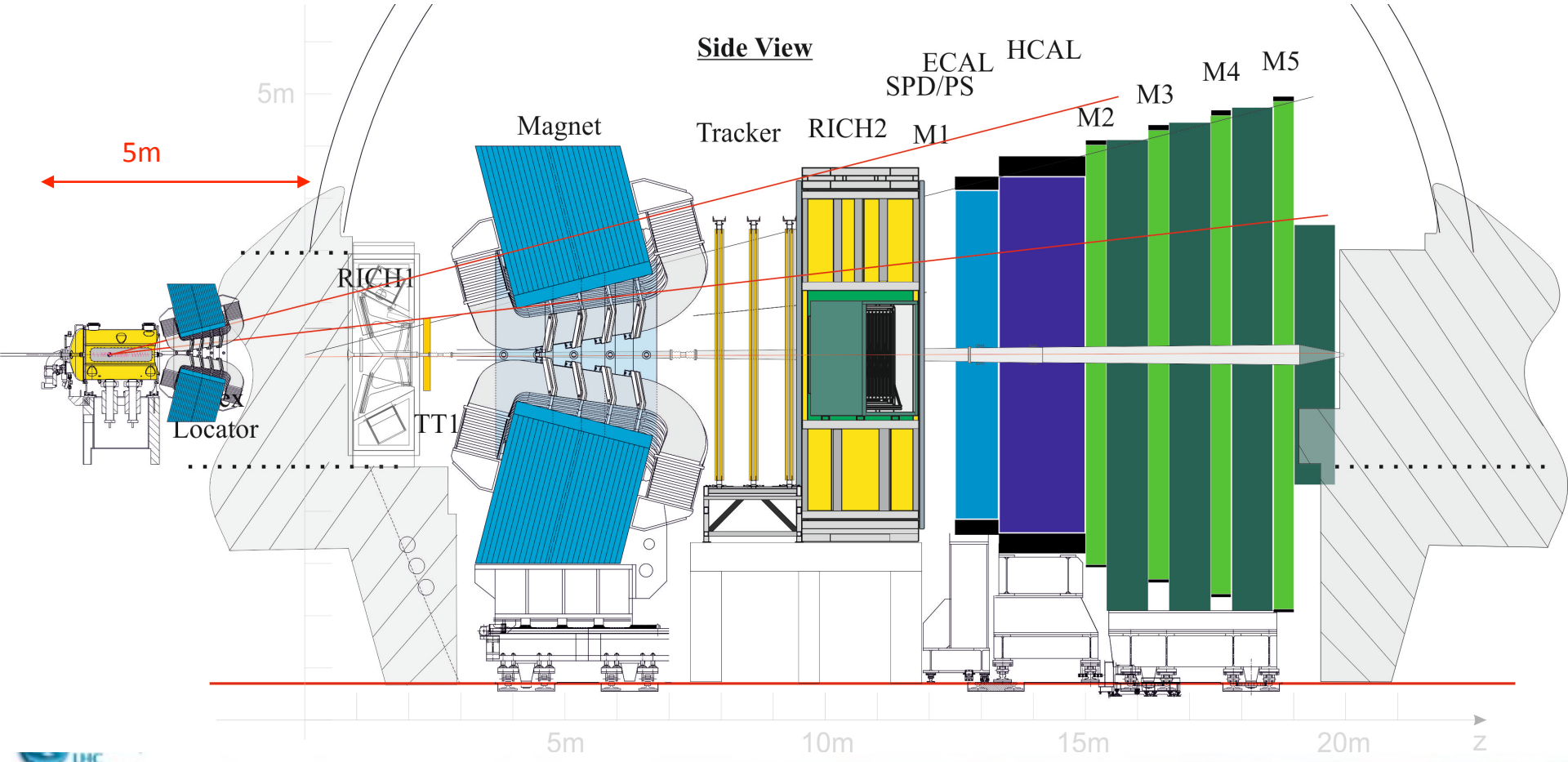
- The shift in IP implies that the experimental area "invades" by **~5m** the LHC tunnel !
  - impact on beam optics, crossing angle definitions
  - re-arrangement of corrector dipoles
    - can we further optimise their length/position/strength wrt the experimental dipoles?

- **Issues to consider - experiment**
  - will the proposed dipole fit in the tunnel?
  - installation/operation of the new dipole and VELO detector

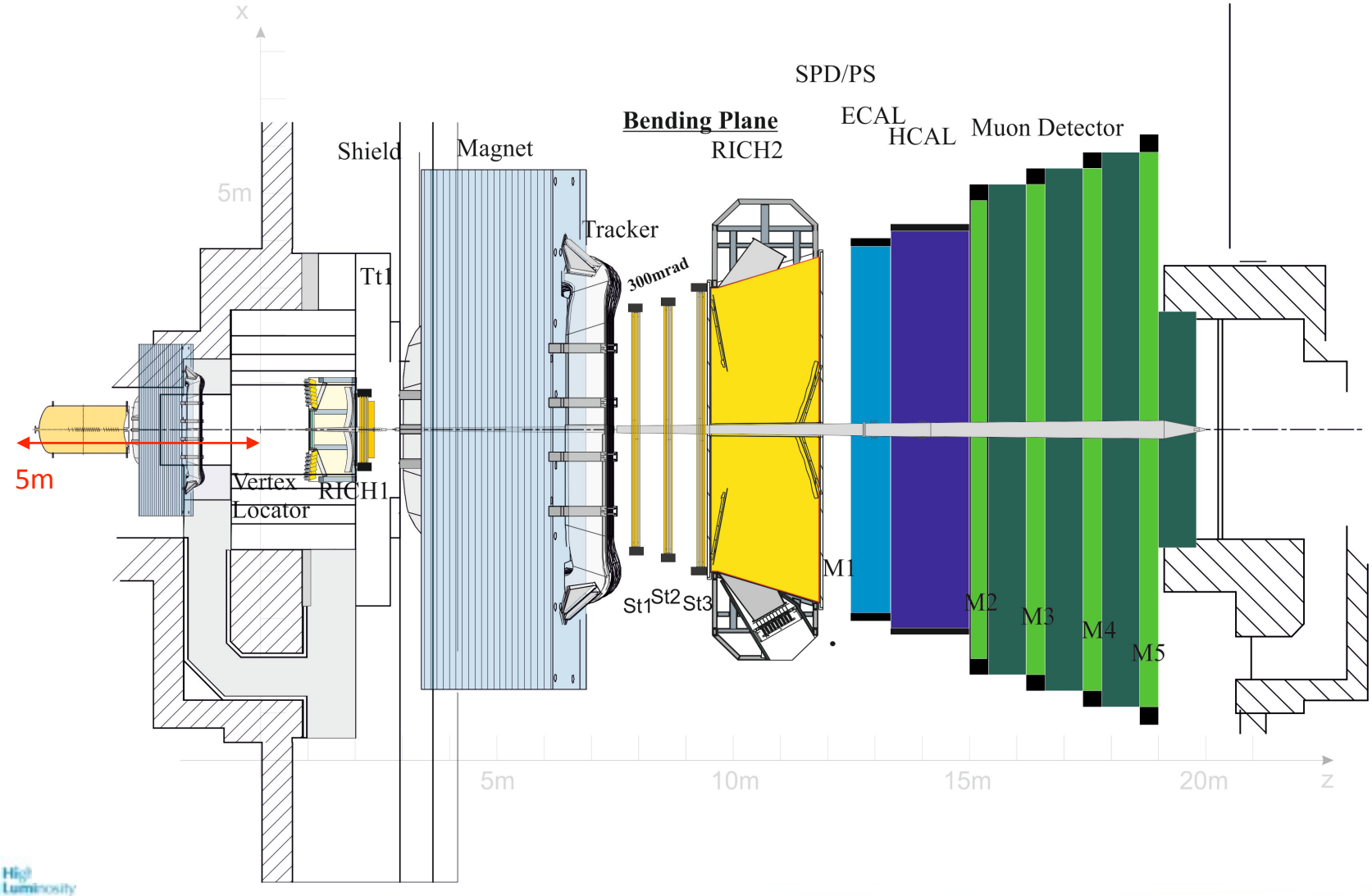
LHCb - present installation



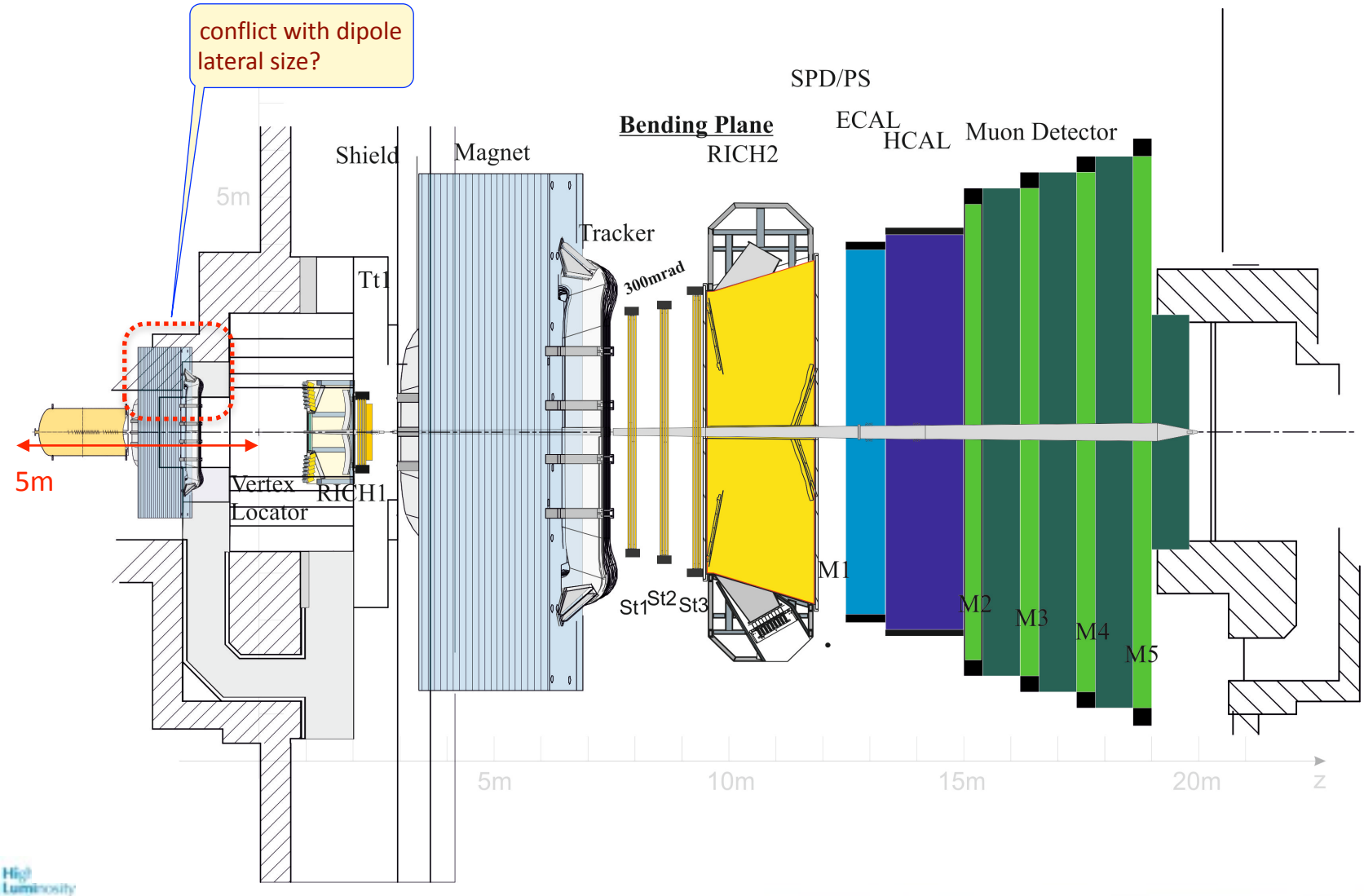
LHCb - future layout (side view)



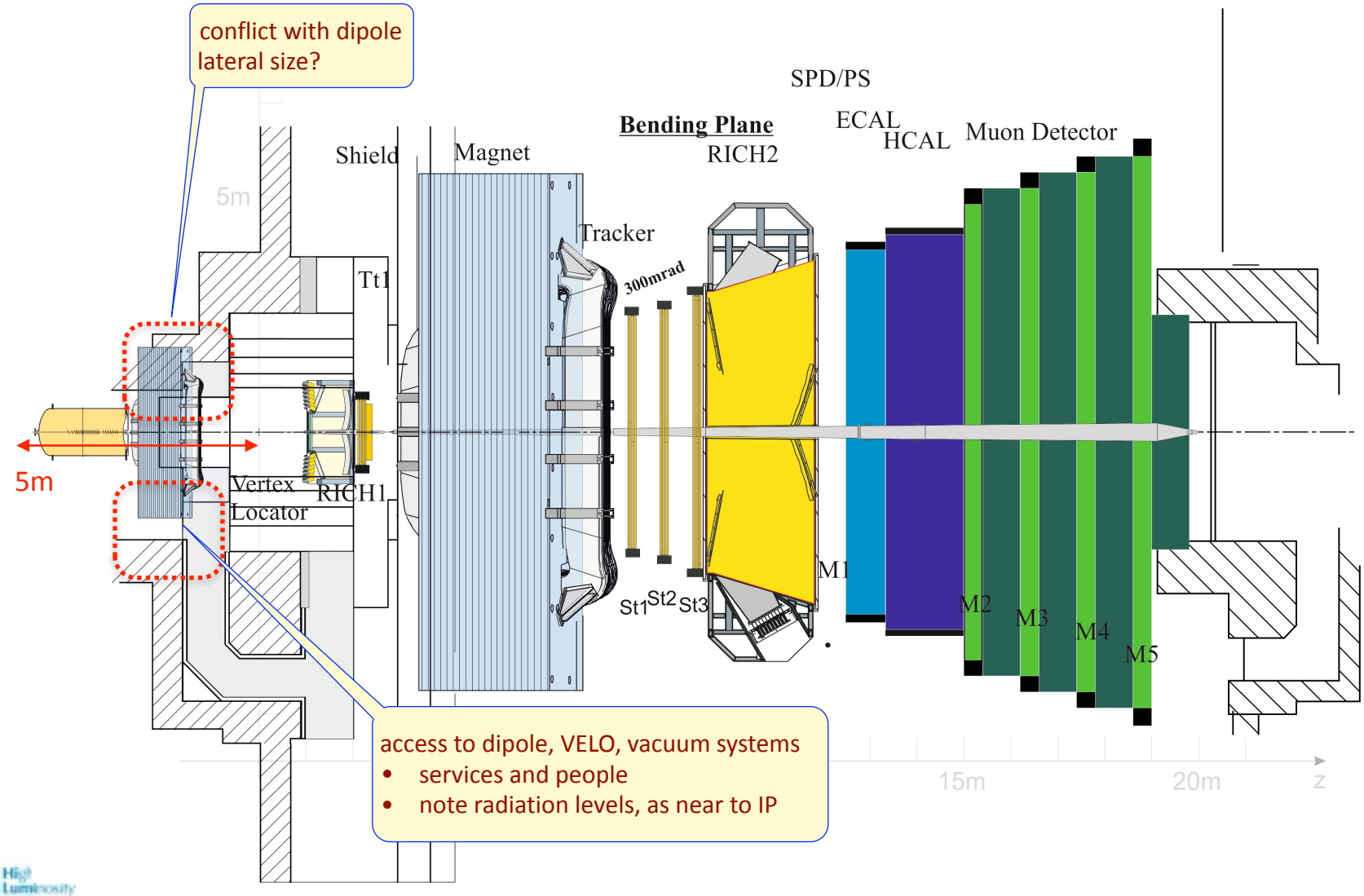
LHCb - future layout (top view)



LHCb - future layout (top view)



LHCb - future layout (top view)



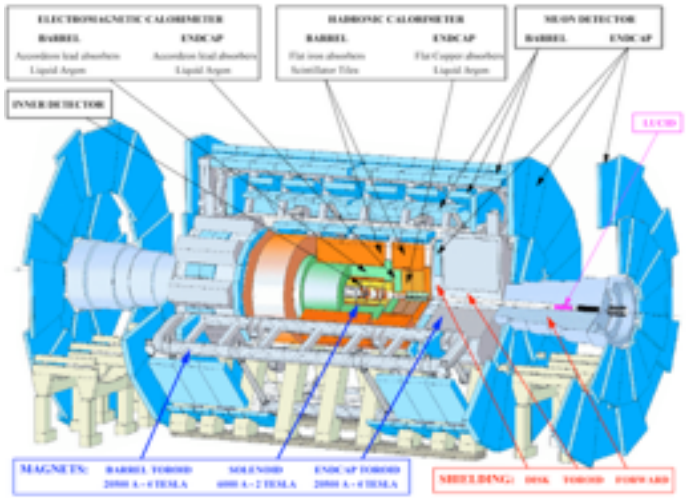
LHCb operation @ LHC nominal luminosity

- **Issues to consider - machine**
  - forward shielding and absorbers : TAS and TAN
    - installation, efficiency, operation, background to experiment
  - collimation system
  - impact on cryogenic systems : cryo-magnets & inftrastructure (QRL..)
  - impact on warm corrector magnets
  - impact on installed infrastructure, including ventilation!

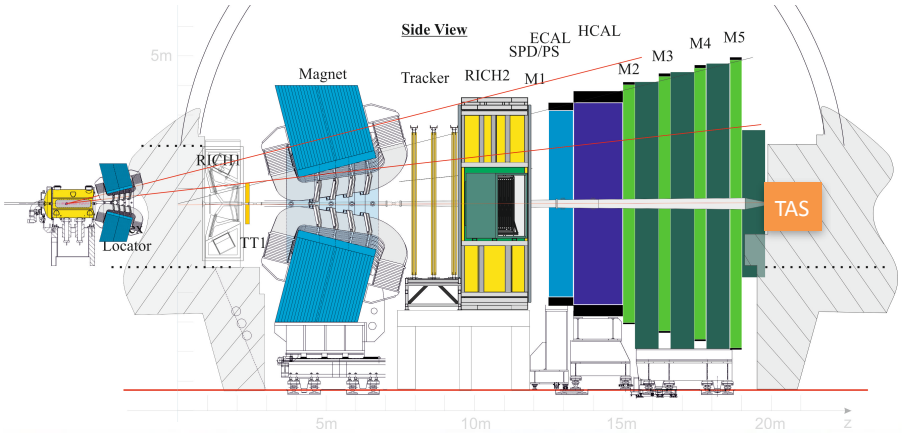
- **Issues to consider - machine & experiment**
  - radiation environment in the LHCb cavern and tunnel
  - integration, operation and maintenance activities - experiment & machine
  - R2E impact on installed electronics for LHC machine systems
    - tunnel, experimental cavern, UJs, ULs

Forward shielding @ absorbers

- ATLAS & CMS : massive shielding in the forward direction to:
  - efficiently protect the LHC machine from collision debris (TAS)
  - minimise background to the detector from back scattering (mainly from the TAS), and from losses in the machine

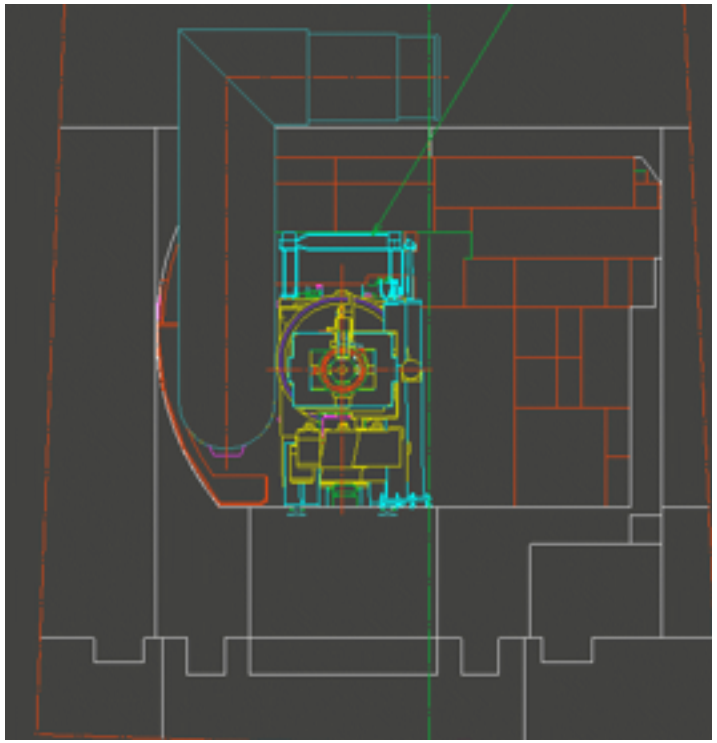


MBXWSH

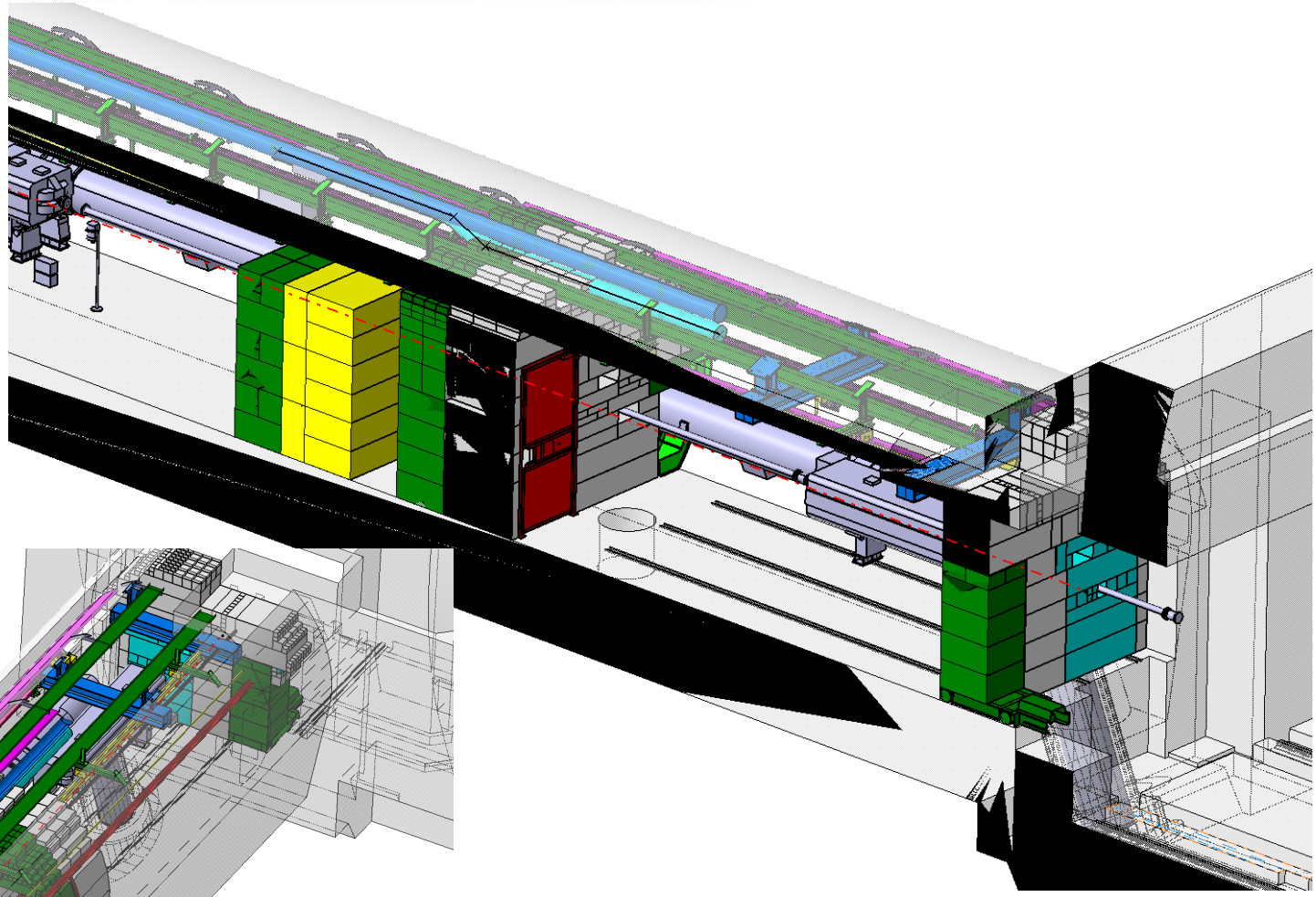


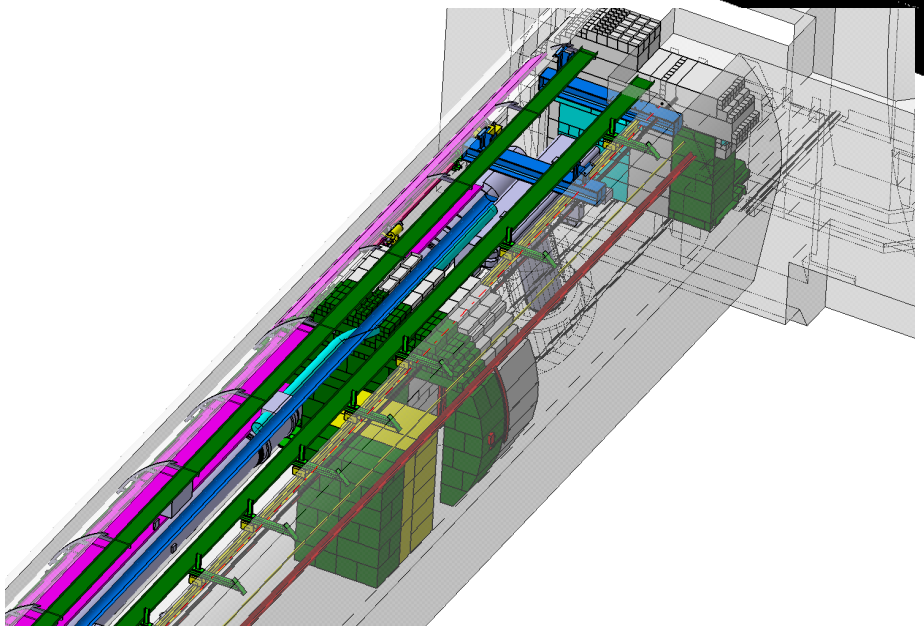
Forward absorbers - TAS

- The TAS is there (mainly) to protect the inner triplet agents (Q1 in particular) from quenching due to collision debris
- In LSS8 between the experiment/IP and Q1 we have the warm magnets/correctors
- **So there is already a TAS!!**
- **Questions** :
  - could a modified shielded MBX dipole efficiently protect Q1?
  - if so, would the MBX survive the radiation? expected lifetime?
  - how about the induced background to the experiment?



RB84





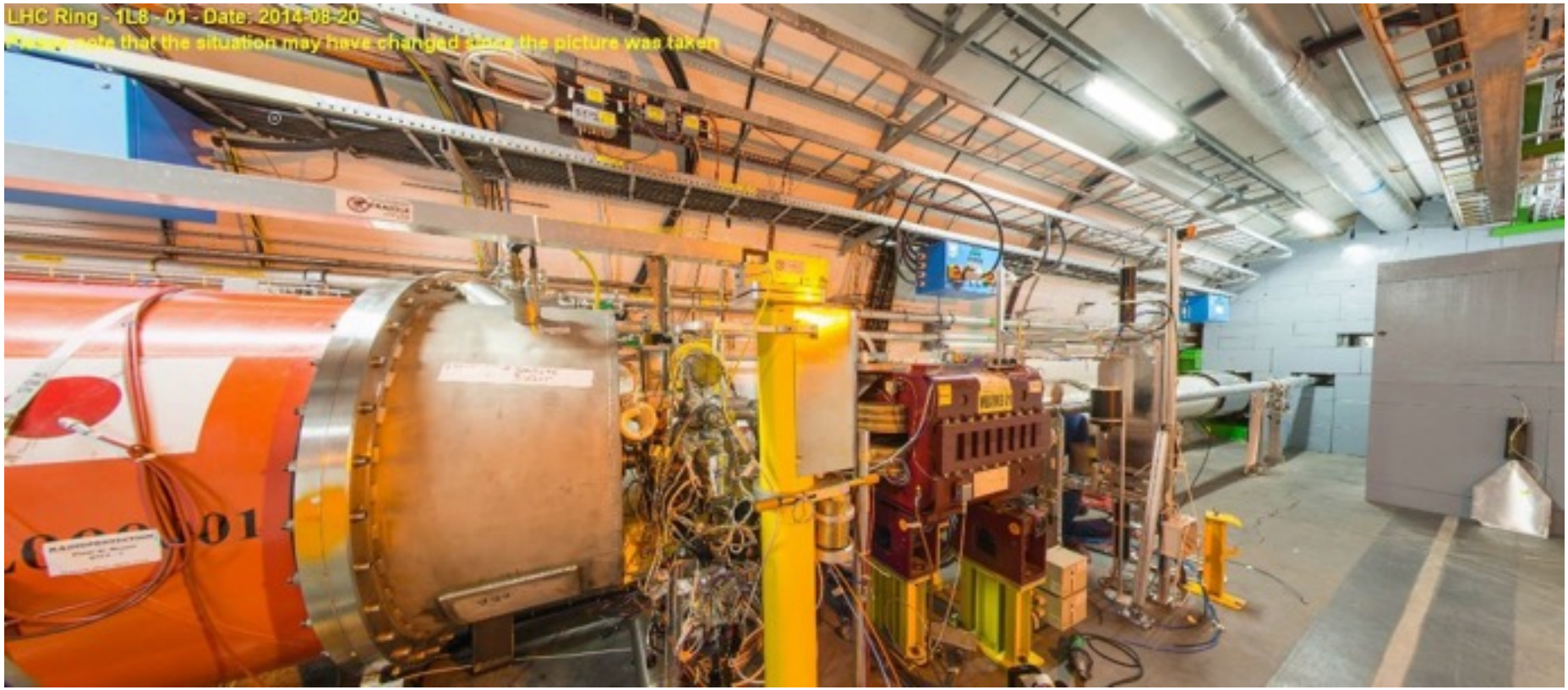
Present LHC Machine layout - C1L8

- The MBXW and shielding wall will have to be displaced by ~5m wrt the present location towards Q1
  - Replace central part of the wall from concrete to Fe/Cu/W to provide sufficient protection to the warm magnet, optimise shielding around to contain radiation in the tunnel and background to the experiment

Present LHC Machine layout - C1L8

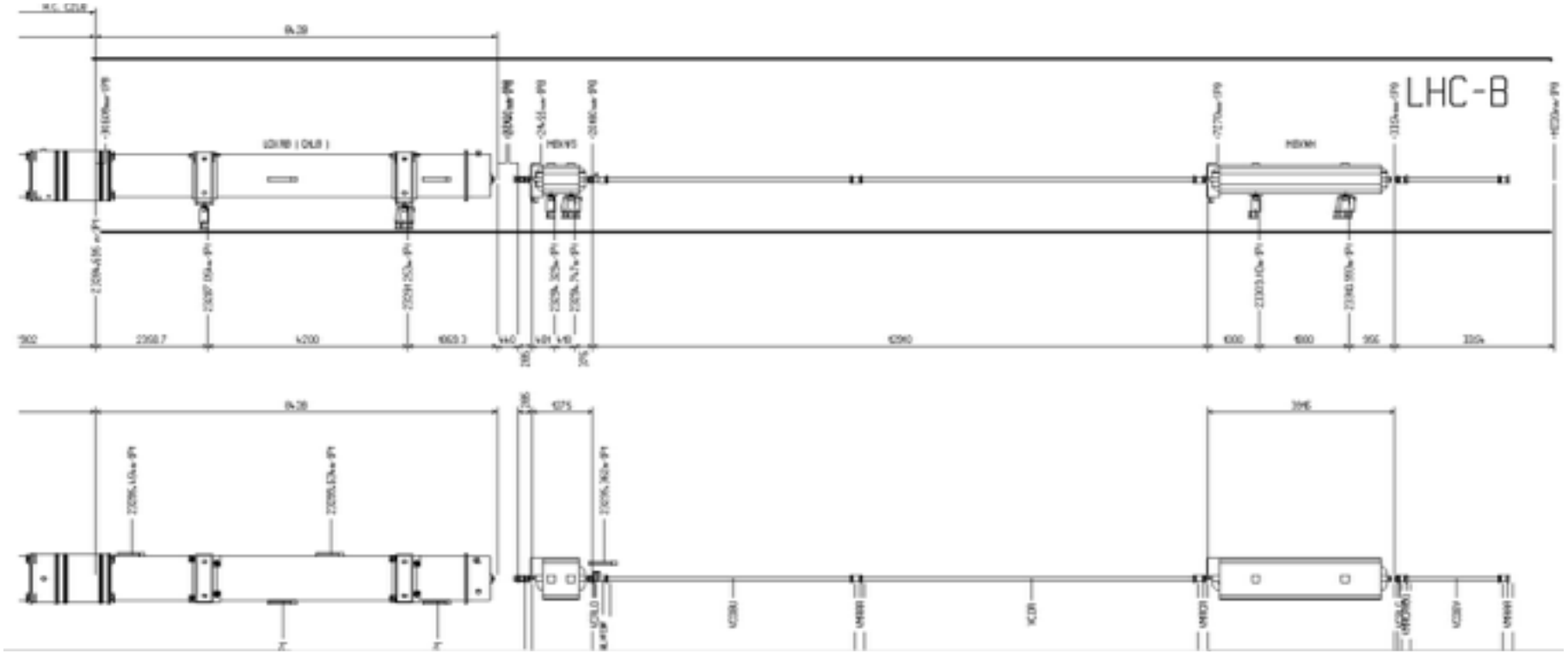
- 2nd shielding wall to be displaced by ~5m, i.e. just upstream the MBXWS
  - best to build it partially around the magnet!

Present LHC Machine layout - C1L8

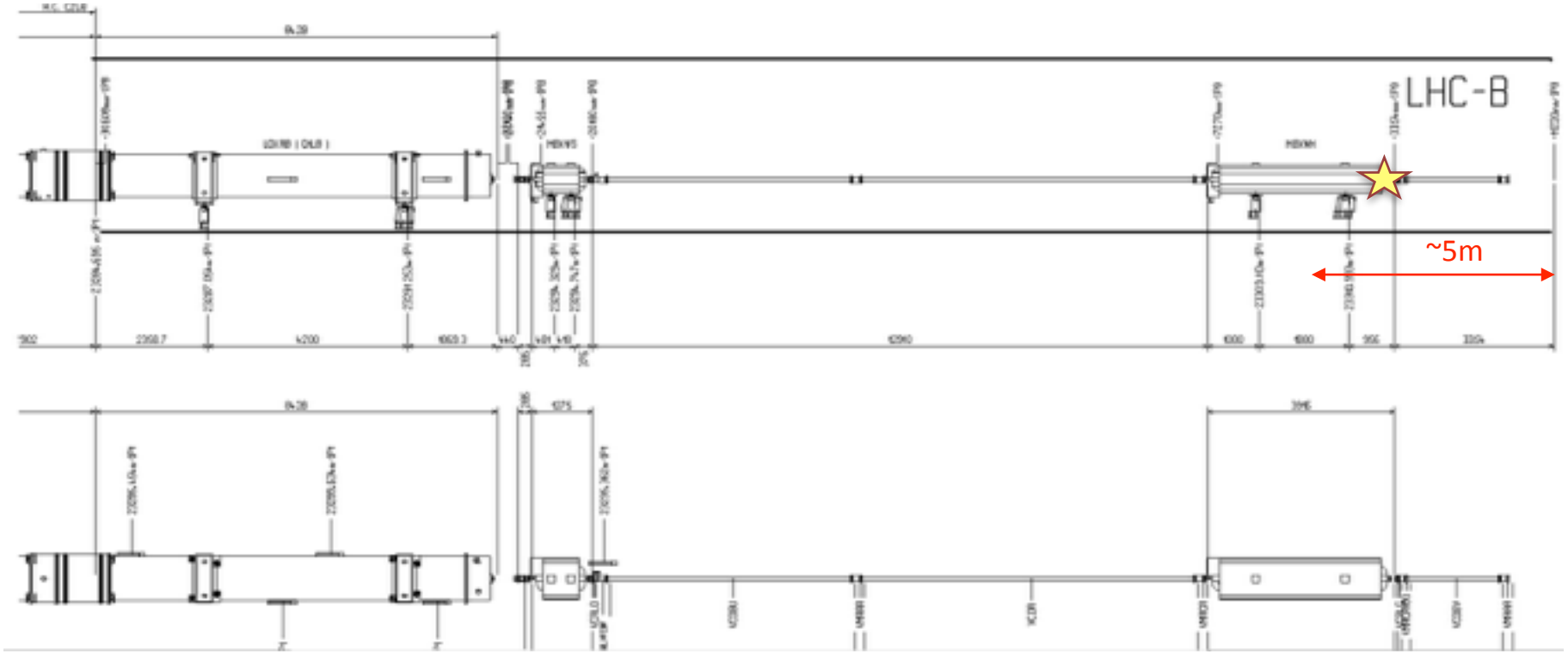


- The MBXWS will be converted to a magnet/TAS combined function equipment - **MBXWTAXS**
- Need to also re-arrange the layout of the vacuum equipment in the region
  - probably an easier case than IP1/IP5 without particular space constraints - but need to work-out the details and the new shielding layout….

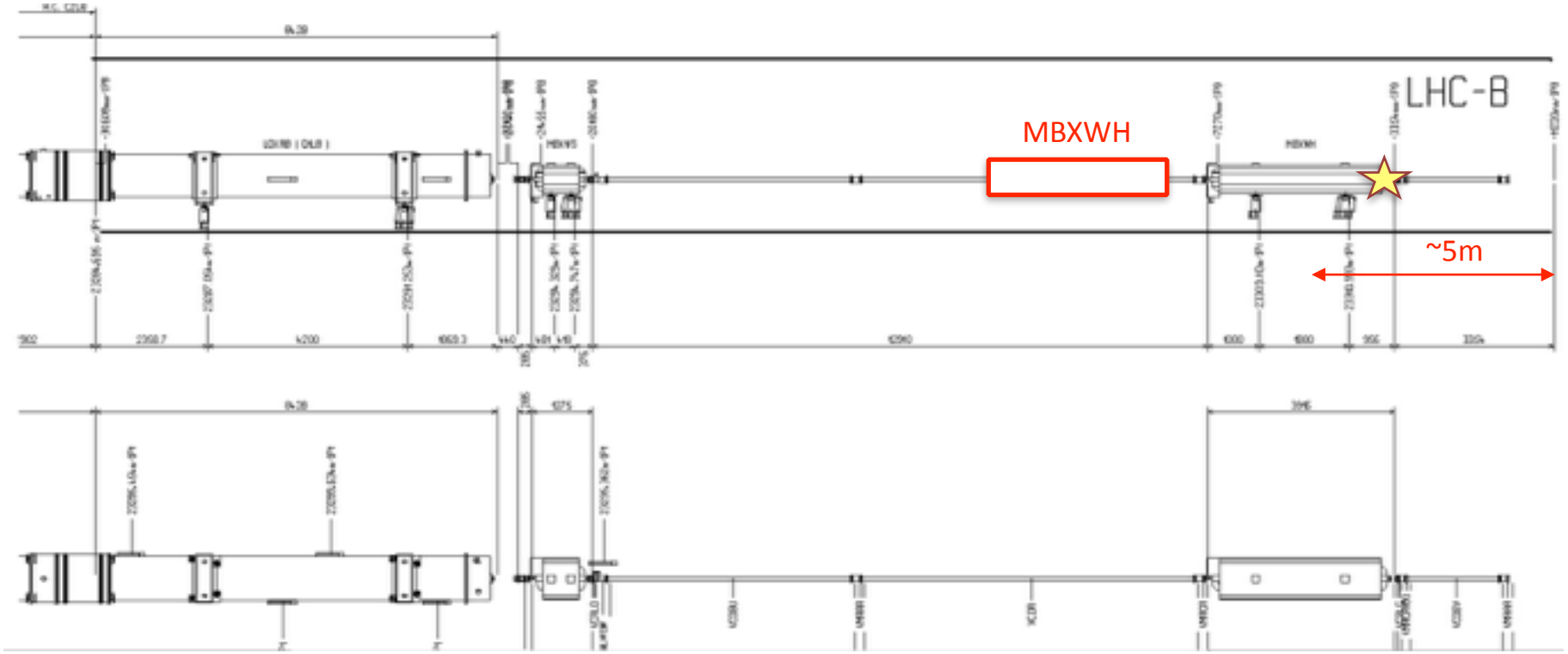
Forward shielding & TAS absorbers -R84



Forward shielding & TAS absorbers -R84

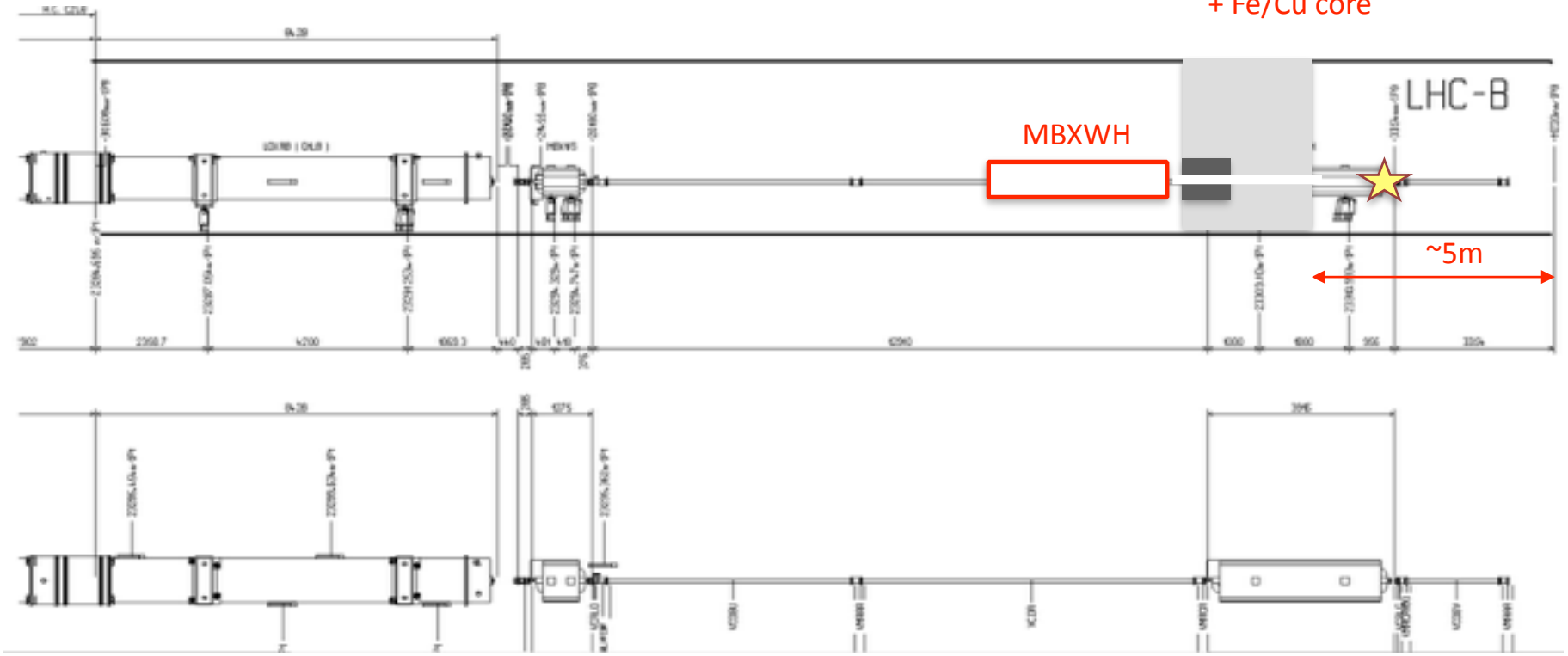


Forward shielding & TAS absorbers -R84



Forward shielding & TAS absorbers -R84

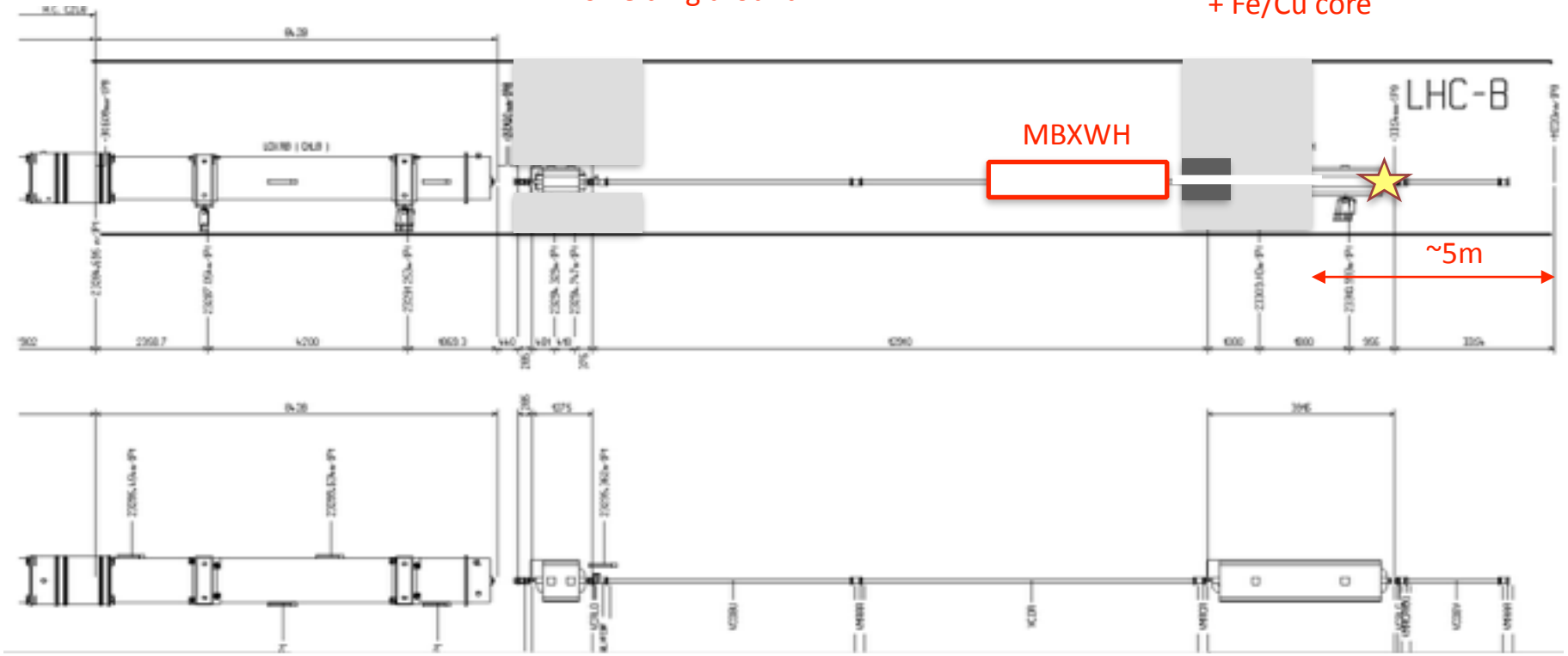
Concrete shielding
(existing wall displaced)
+ Fe/Cu core



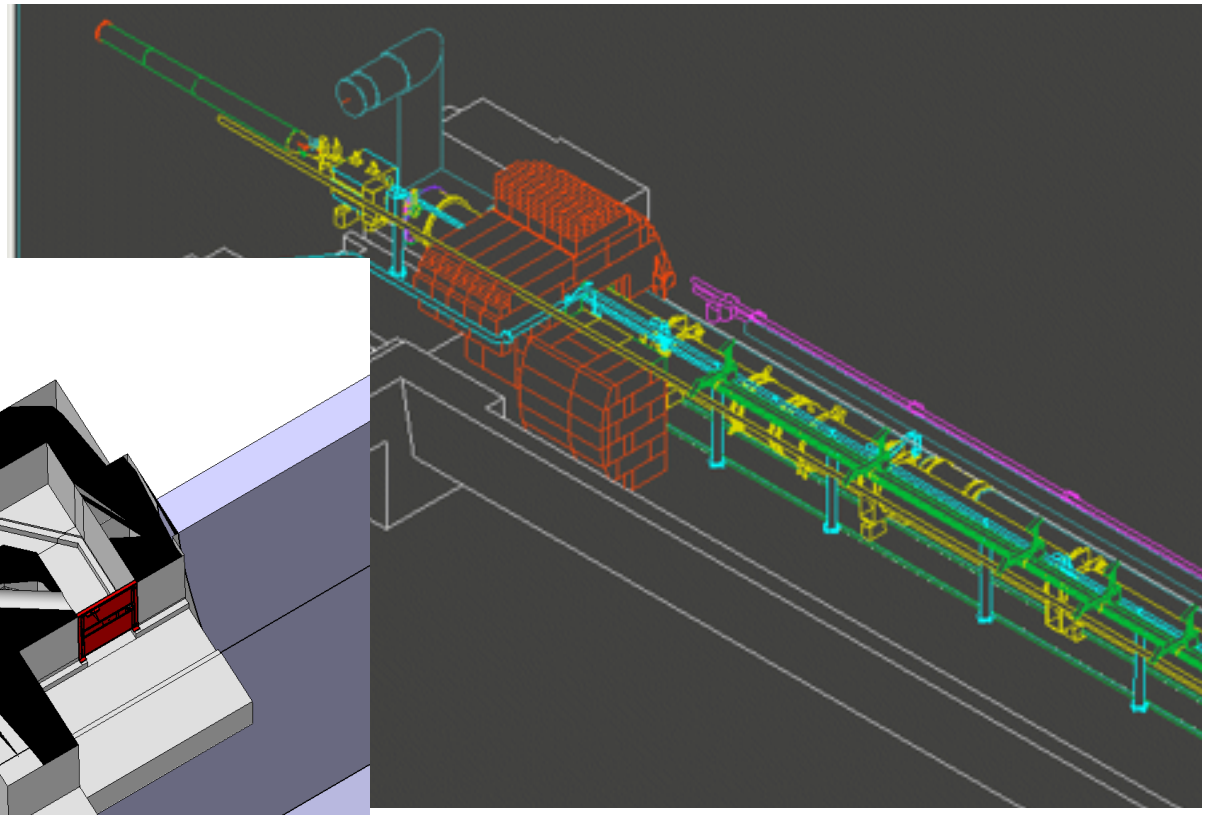
Forward shielding & TAS absorbers -R84

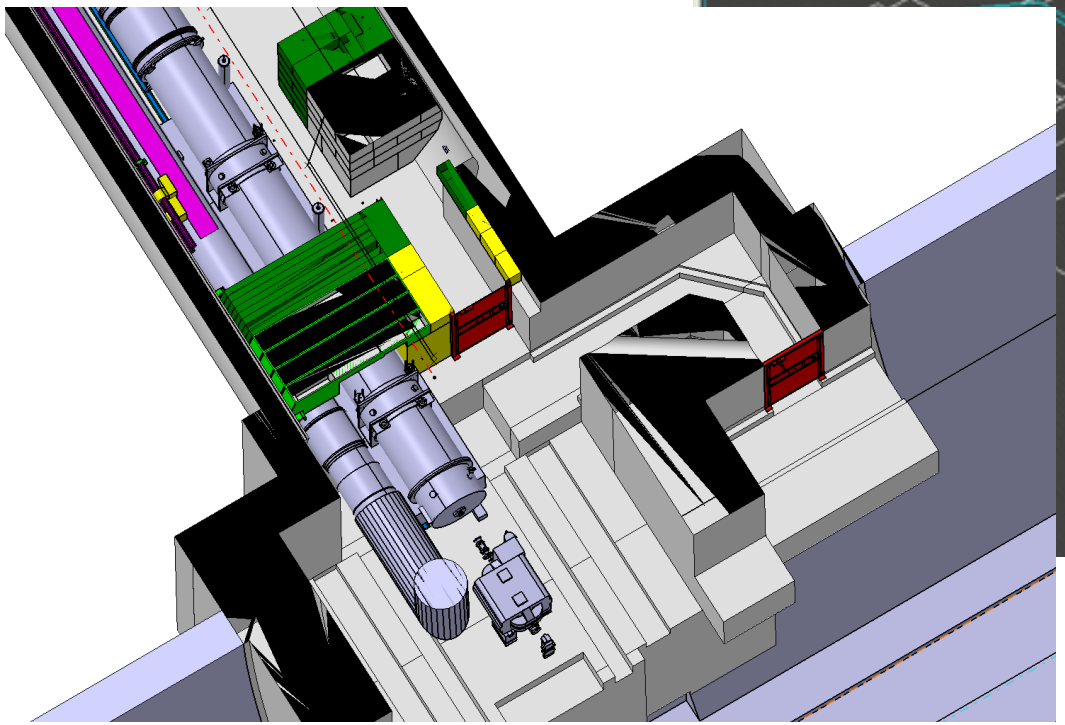
TAS
reinforced MBXWS
+ shielding around

Concrete shielding
(existing wall displaced)
+ Fe/Cu core



RB86

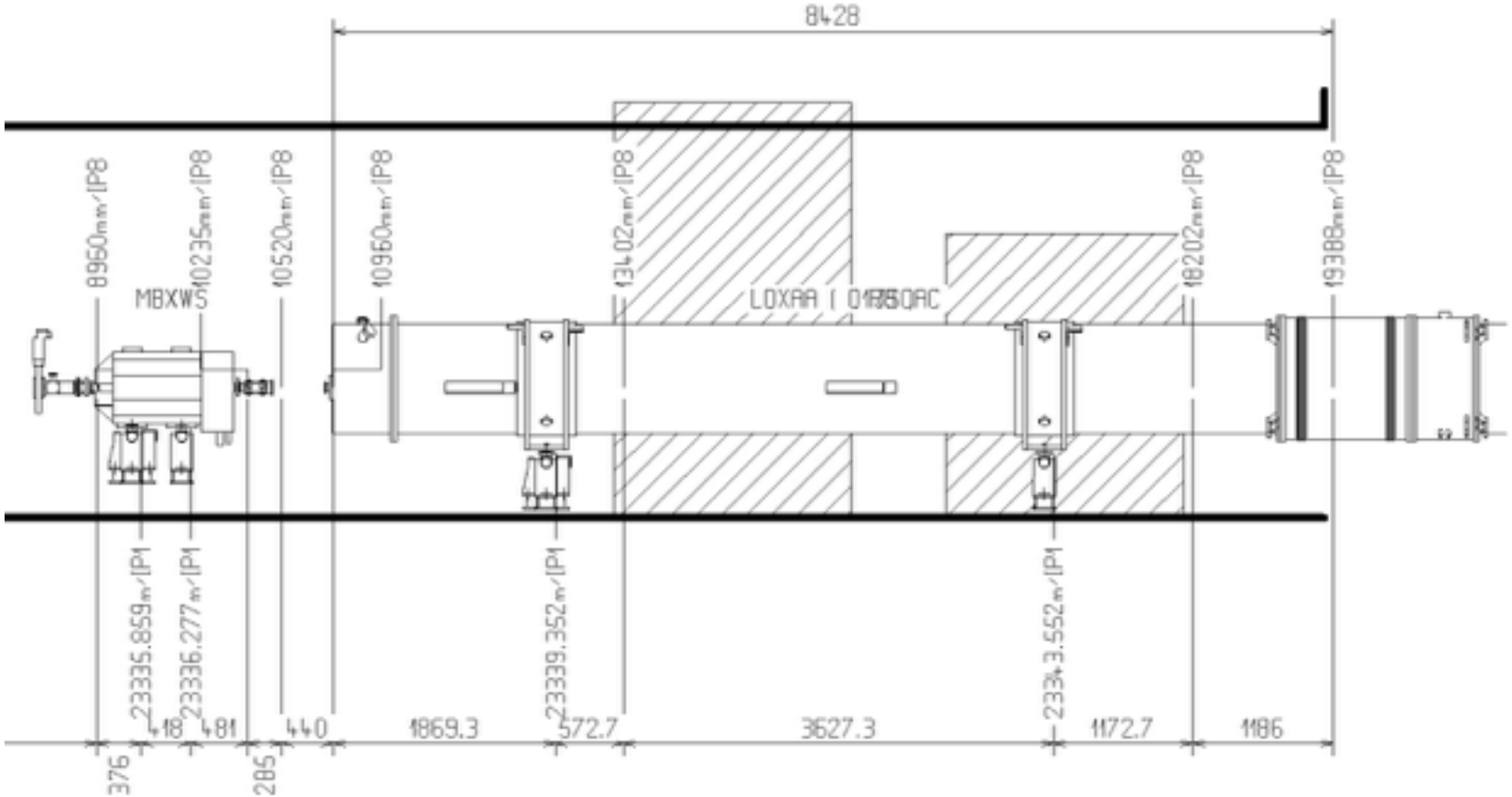




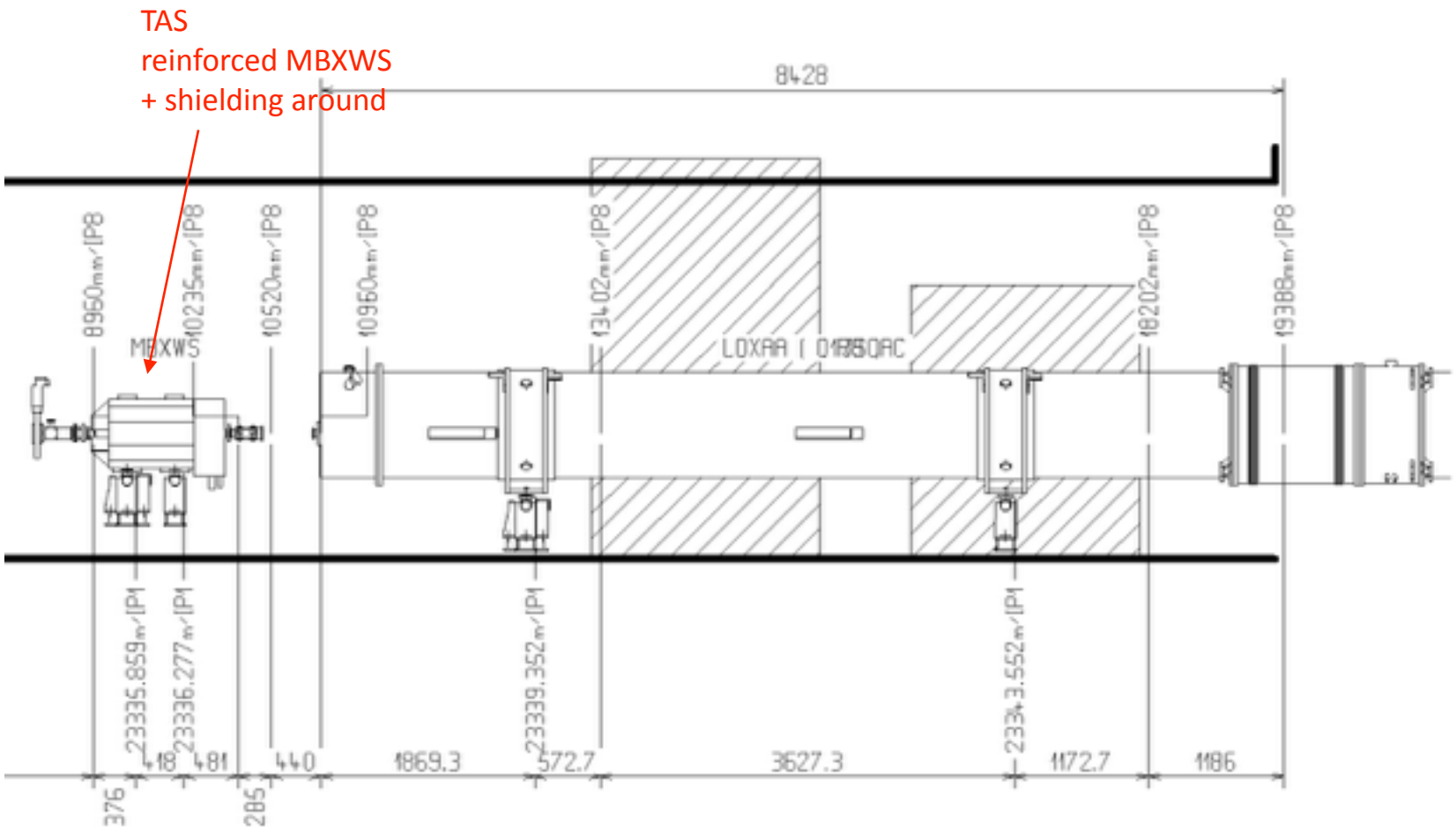
Present LHC Machine Layout - C1R8

- New MBXWS to construct with higher (+30%) field also converted to **MBXWTAXS**
  - W inserts to close the magnet yoke and screen in front
  - rearrange vacuum equipment such to close as much as possible the opening in the green shielding
  - add some additional shielding around the magnet to control the remnant radiation in the area

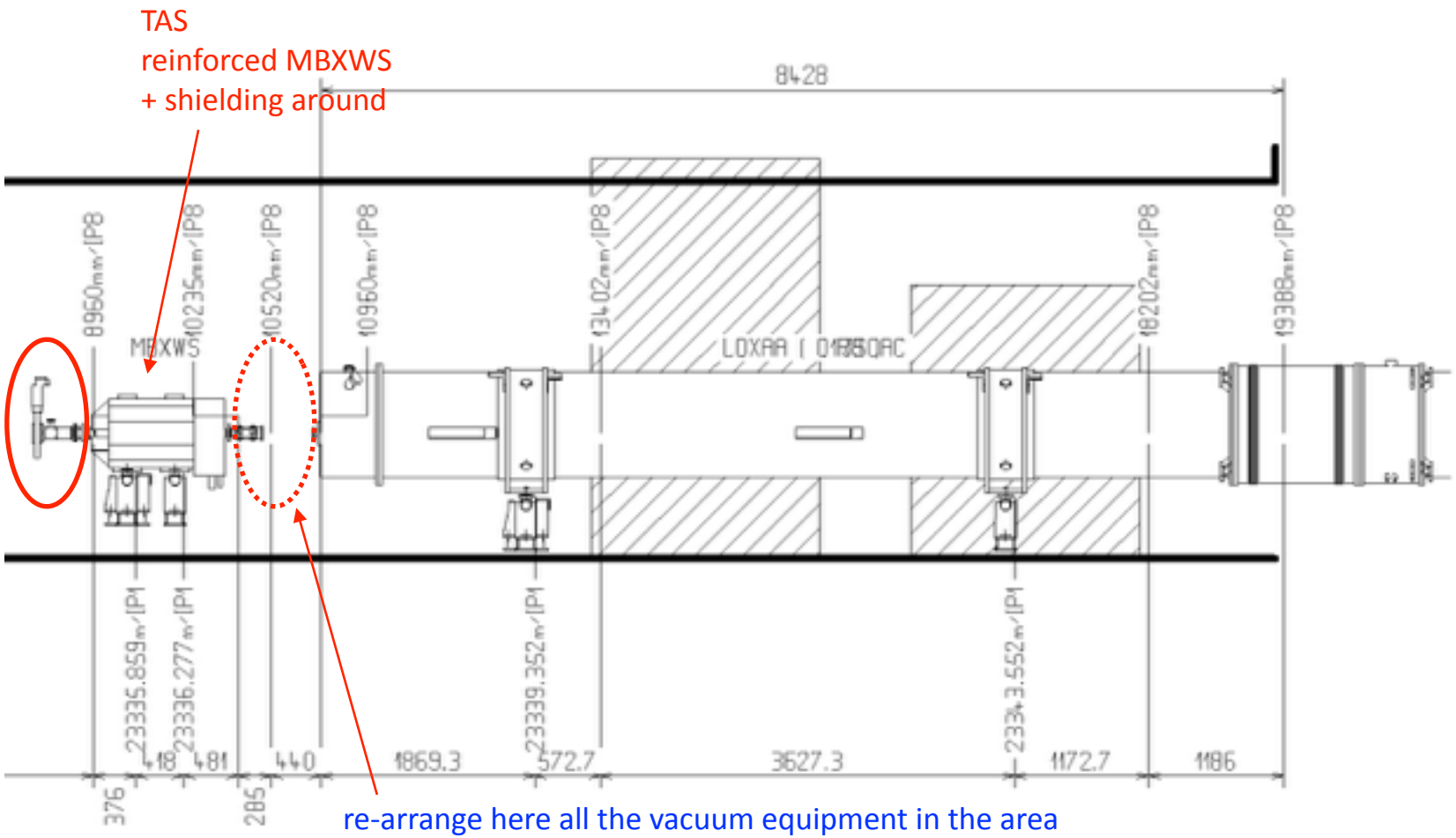
Forward shielding & TAS absorbers - R 86



Forward shielding & TAS absorbers - R 86

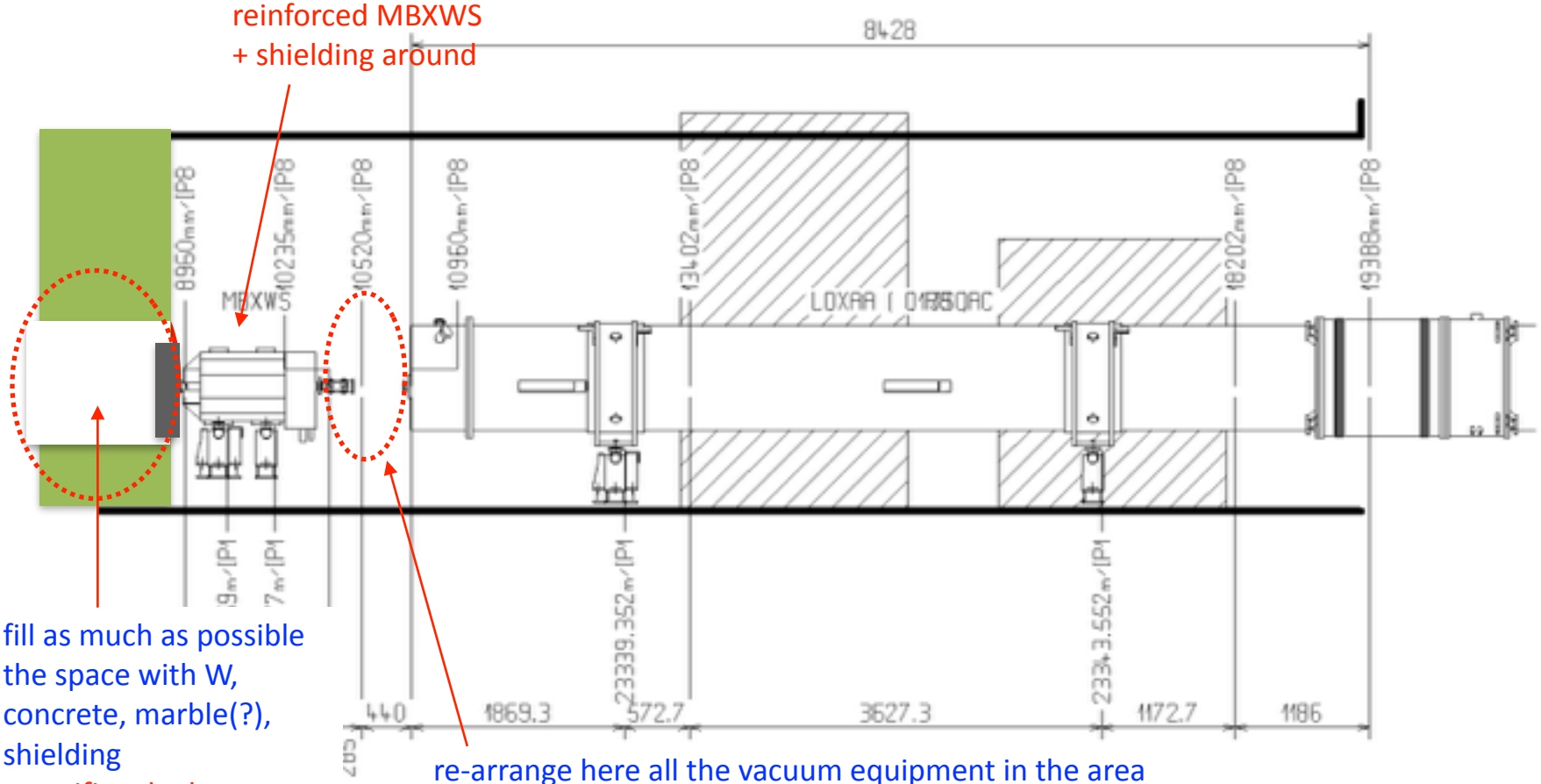


Forward shielding & TAS absorbers - R 86



Forward shielding & TAS absorbers - R 86

TAS
reinforced MBXWS
+ shielding around

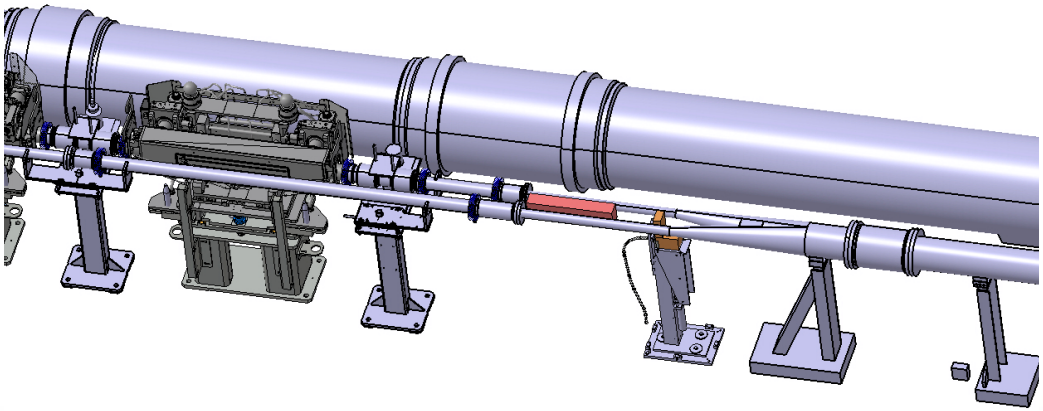


fill as much as possible the space with W, concrete, marble(?), shielding
- sacrifice the last muon layer ???

re-arrange here all the vacuum equipment in the area
- challenging task for the vacuum team, but need to look into the details…

Forward shielding - TAN absorbers

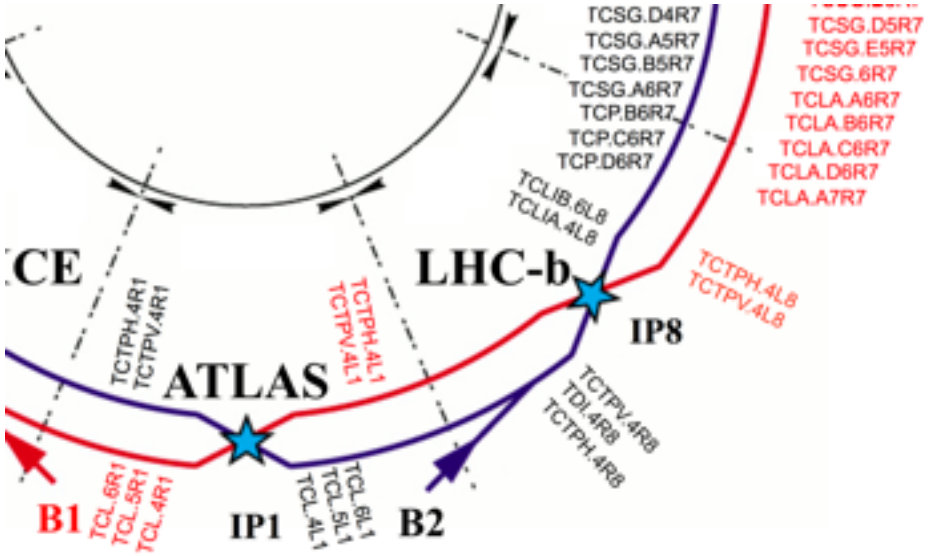
- A mini-TAN is foreseen to be installed during LS2 - solution for 10^{33} operation
  - full TAN functionality = mini-TAN at the junction chamber + mask in-front of D2
- Need to understand from the energy deposition studies if this configuration could be sufficient for nominal luminosity
  - critical impact of the x-sing angle
  - evaluate the option to include in the design of the min-TAN the conversion to a full-TAXN solution (short W-version)



Collimation system

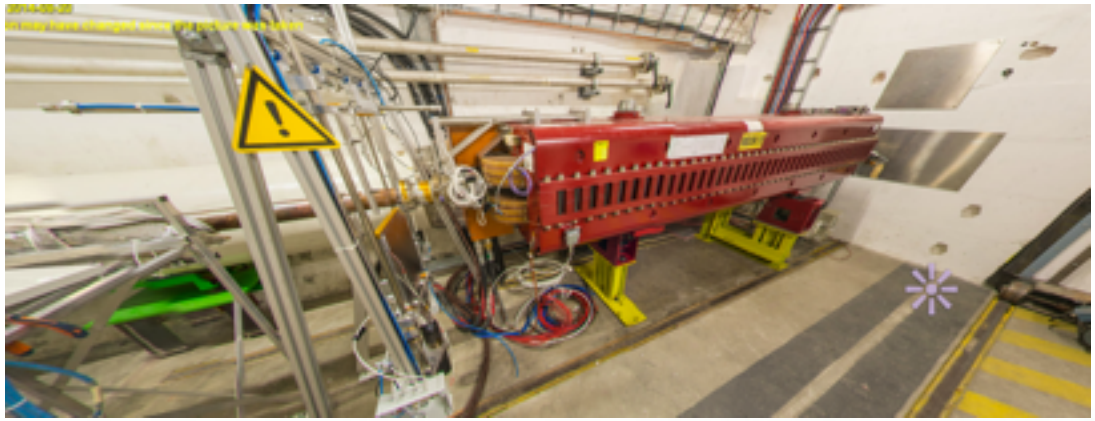
- Must convert the IP8 to a similar layout as today's high-limi points IP5/IP5.
- Depending on the optics we might need new collimators for the incoming beam cleaning
- We may also need some TCLs downstream, that were discussed but not included in the present HL budget

- **Question** : do we need additional protection for the incoming injected beam?
  - in principle no, the incoming beam protection should not depend on the resulting luminosity at IP8 after the machine is filled



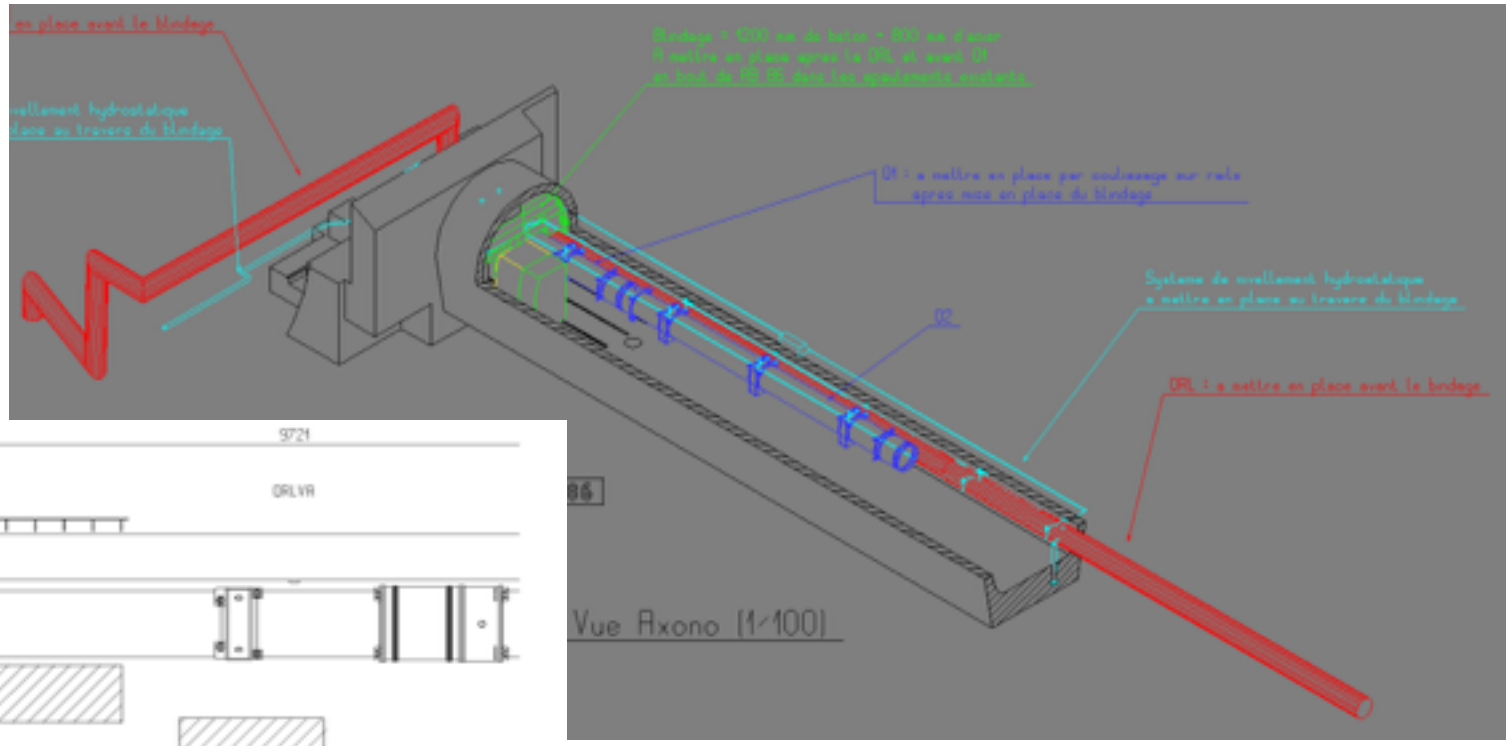
Impact on cryogenic systems

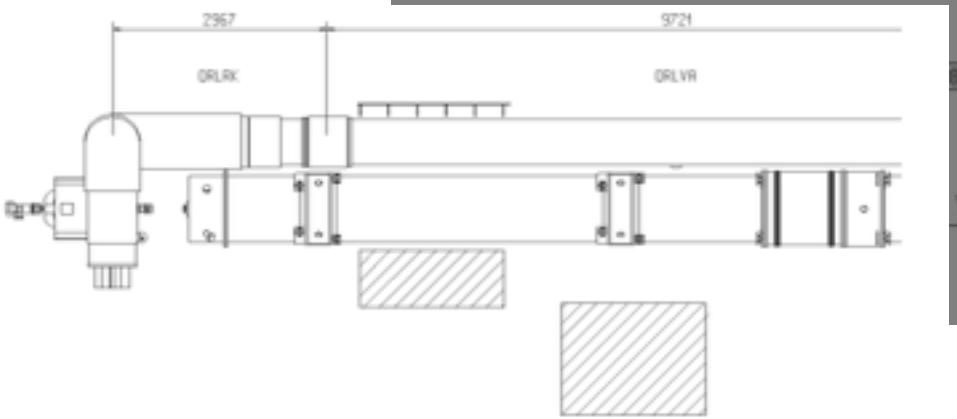
- What is involved?
  - cryogenic installation in UX85
  - increased load due to collision debris on the triplet magnets
  - increased **heat load** in the adjacent QRL line and **radiation impact** on its lifetime
    - the existing QRL line in R84 would be at 1m distance from the foreseen new IP position
    - also a layout issue for the new experimental dipole and new VELO



Cryogenic systems - QRL line

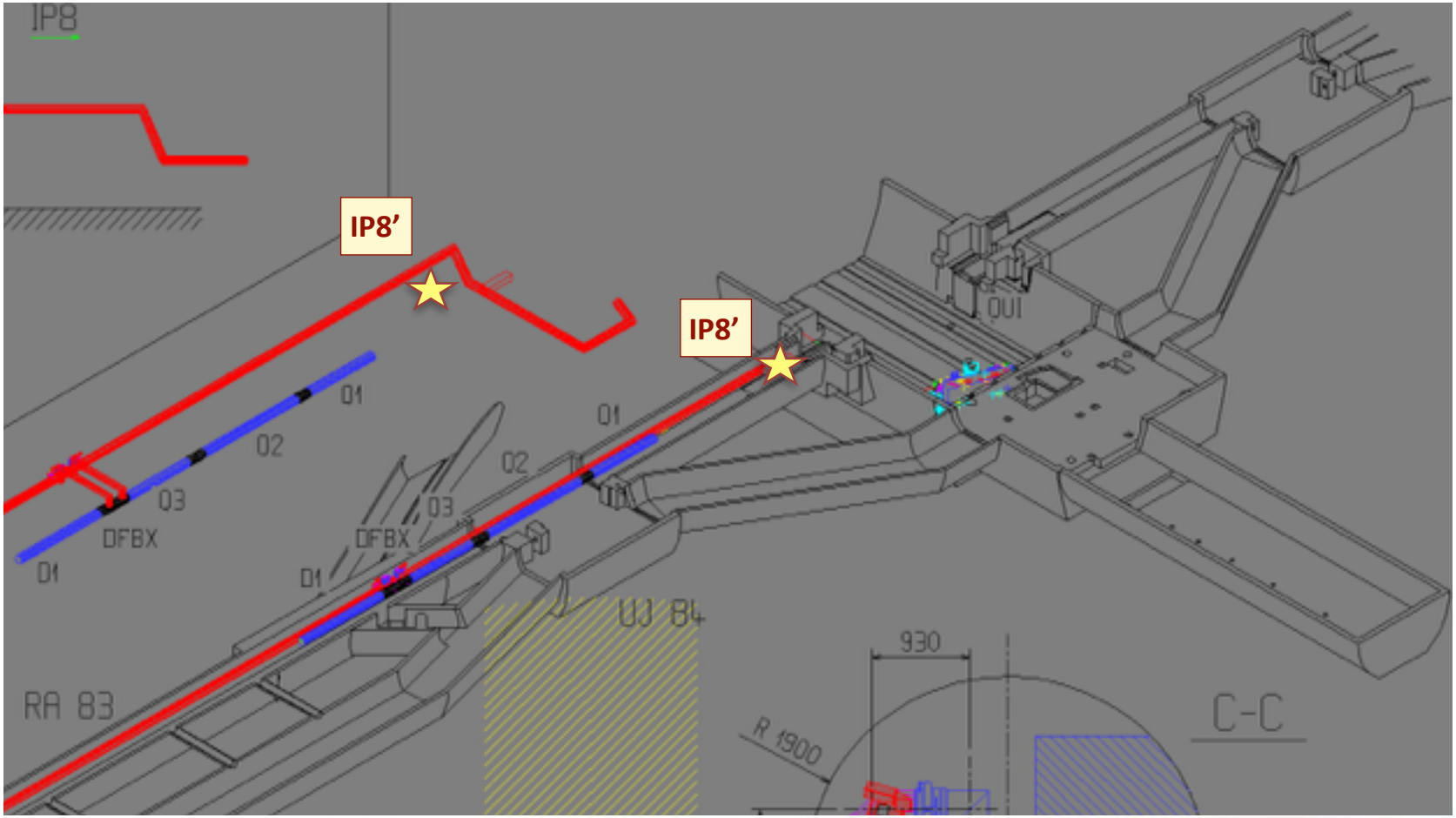
- R86 side - probably not an issue, line already embedded in the forward shielding





Cryogenic systems - QRL line

- R84 side - very close to the foreseen IP position
  - finding another path may require CE works in the region - to be studied!



Impact on other systems

- Installed vacuum equipment around the MBXs
  - need to optimise the installations and interventions
- Must understand the radiation levels in the LSS to check if other equipment need to be displaced to protect from R2E effects
  - probably the option to have the IP displaced in the LHC tunnel may be favourable!
- Impact on general services in the tunnel in the region
  - think the most trivial ones: lighting !!!
  - ventilation : must check radiation impact on air activation and access scenarios
- Planning?
  - should we anticipate some of the works during LS3 ?
  - would depend on how much we would know by 2022 !!

Summary

- Converting LHCb zone considered as a low-luminosity interaction region to a **nominal IP** is a challenging problem but not so dramatic as may sounds!

- A first look on the layout with displaced IP is done
  - Inserting the forward shielding is a critical issue - a possible solution for a TAS and shielding arrangement is found, that needs to be further developed.
  - The impact on other machine equipment like the QRL line needs to be carefully looked studied.
  - Small working group to continue to work on the layout details and simulations [energy deposition, efficiency, radiation containment] to validate the options

- The impact on **maintenance** and **operation** of the installations in the **experimental cavern** and nearby **tunnels** needs to be studied in detail. We should not create a **weak point in the LHC ring** in terms of equipment failures and **dose** during interventions
  - example: if we go towards the MBXWTAXS solution, a failure in one of these magnets, example on R86 side, would imply a stop for LHCb physics, but also lot of time to during a TS or YETS to exchange them ⇒ need to work out an optimised way for this exchange that involves moving large masses of shielding!

Thanks to LHCb for the challenge!!! - it would be a fun project to work, if good physics is to be found!