Material and engineering considerations for the nozzle

IMCC and MuCol MDI workshop 2024

11 March 2024, CERN

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CERN – Systems Department, Sources Targets Interaction (STI), Targets Collimators Dumps (TCD)

Content

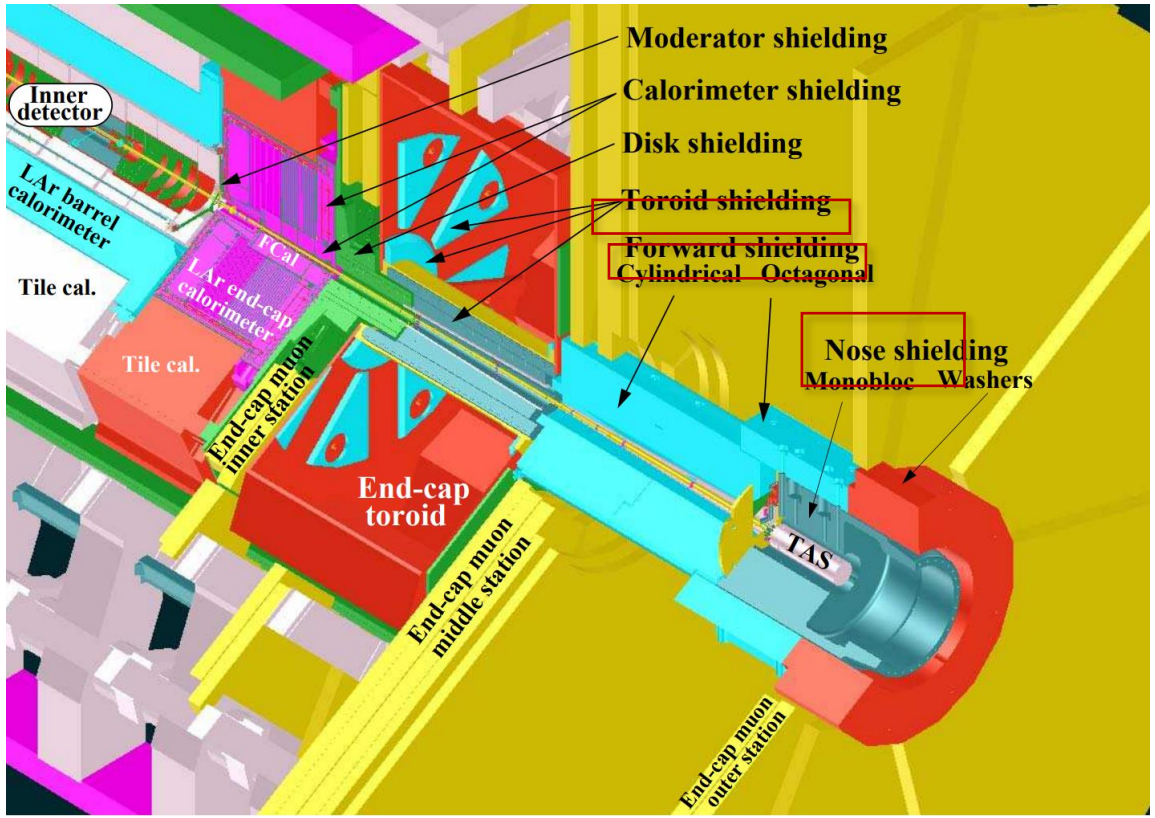
- Examples (ATLAS)
- MDI shielding - Very first considerations
- Conclusions

ATLAS

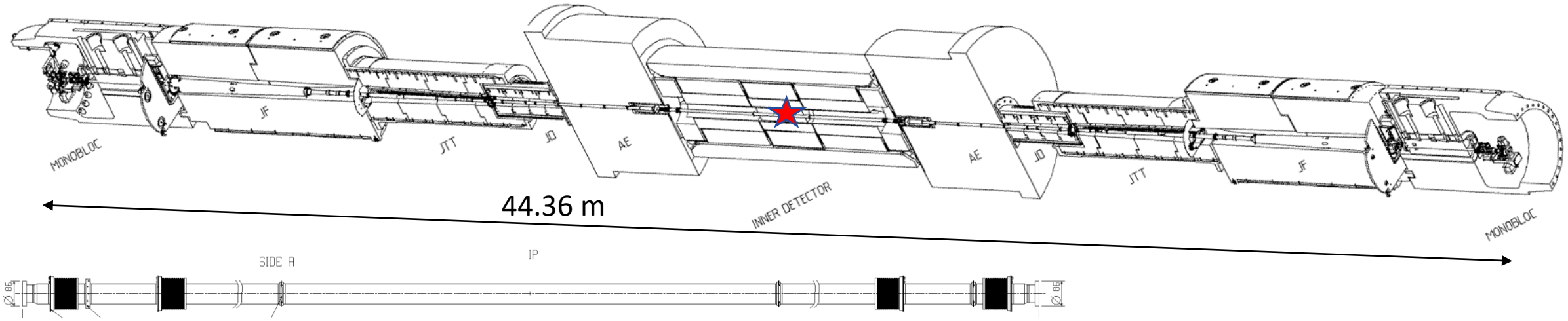
- Multilayer shielding to reduce the number of background particles & protect people from radiation due to secondary particles (neutrons/hadrons/photons).
  - Moderator shielding (JM)
  - Disk Shielding (JD)
  - **Toroid Shield (JT)**
  - Forward shielding (JF)
  - Nose Shielding (JN)

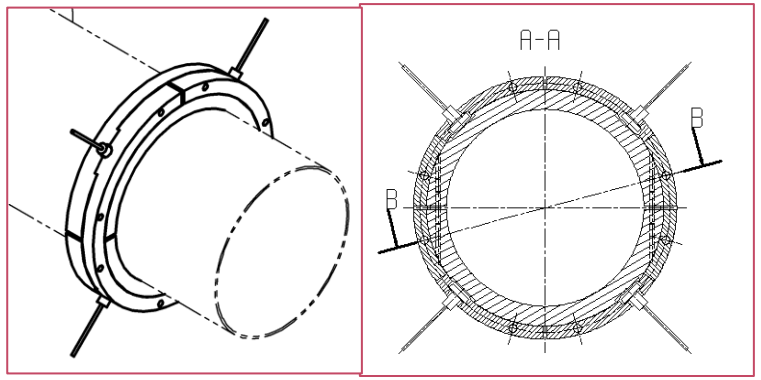
- 1887 tonnes metal
- 920 tonnes of concrete
- 18 tonnes of plastic

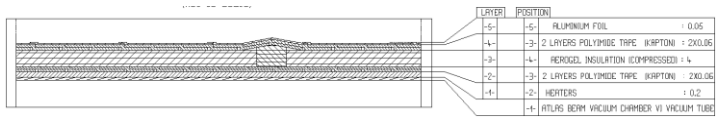
10.1088/1748-0221/3/08/S08003
https://atlas-shielding.web.cern.ch



ATLAS – shielding and beampipe







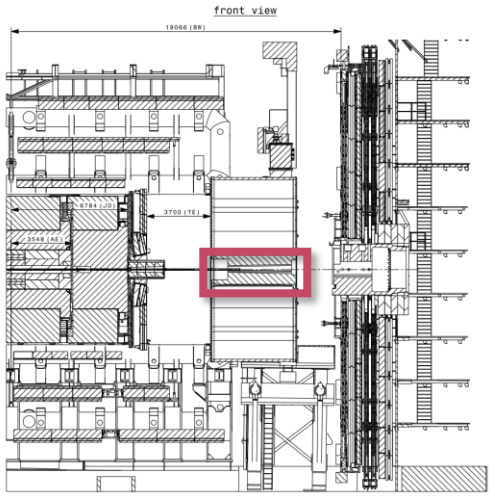
Beam pipe overview

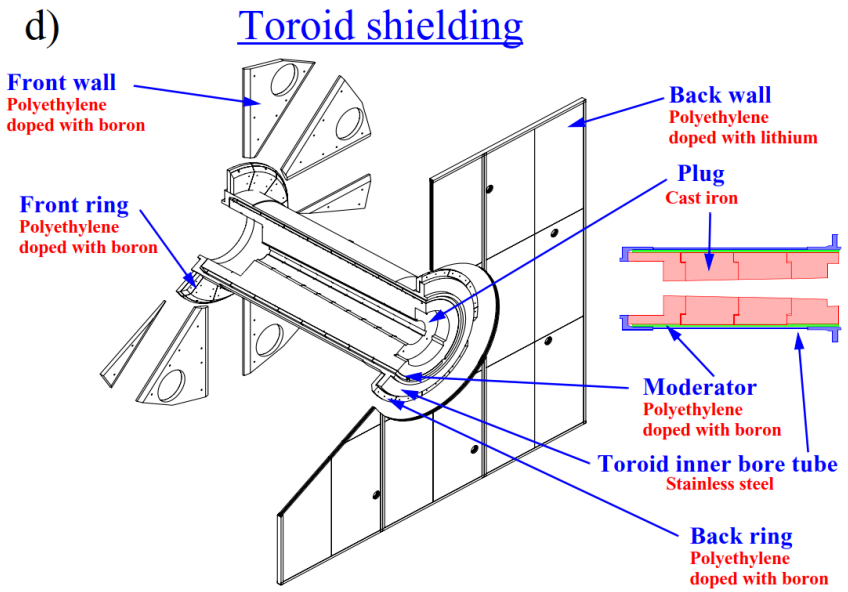
- (VI) Inner beampipe made of 100 (Al) + 7100 (Be) + 100(Al). D58 mm x 0.8mm thick. Installed at the surface with detector.
- + other 6x SS(or Al?) chambers (VA, VT, VJ).
- Different supporting systems (sliding supports, retractable jacks on rails, cantilevered)
- NEG coated, heaters, thermocouples, insulation.
- Minimized bellows interconnects.
- Baked-out in situ.

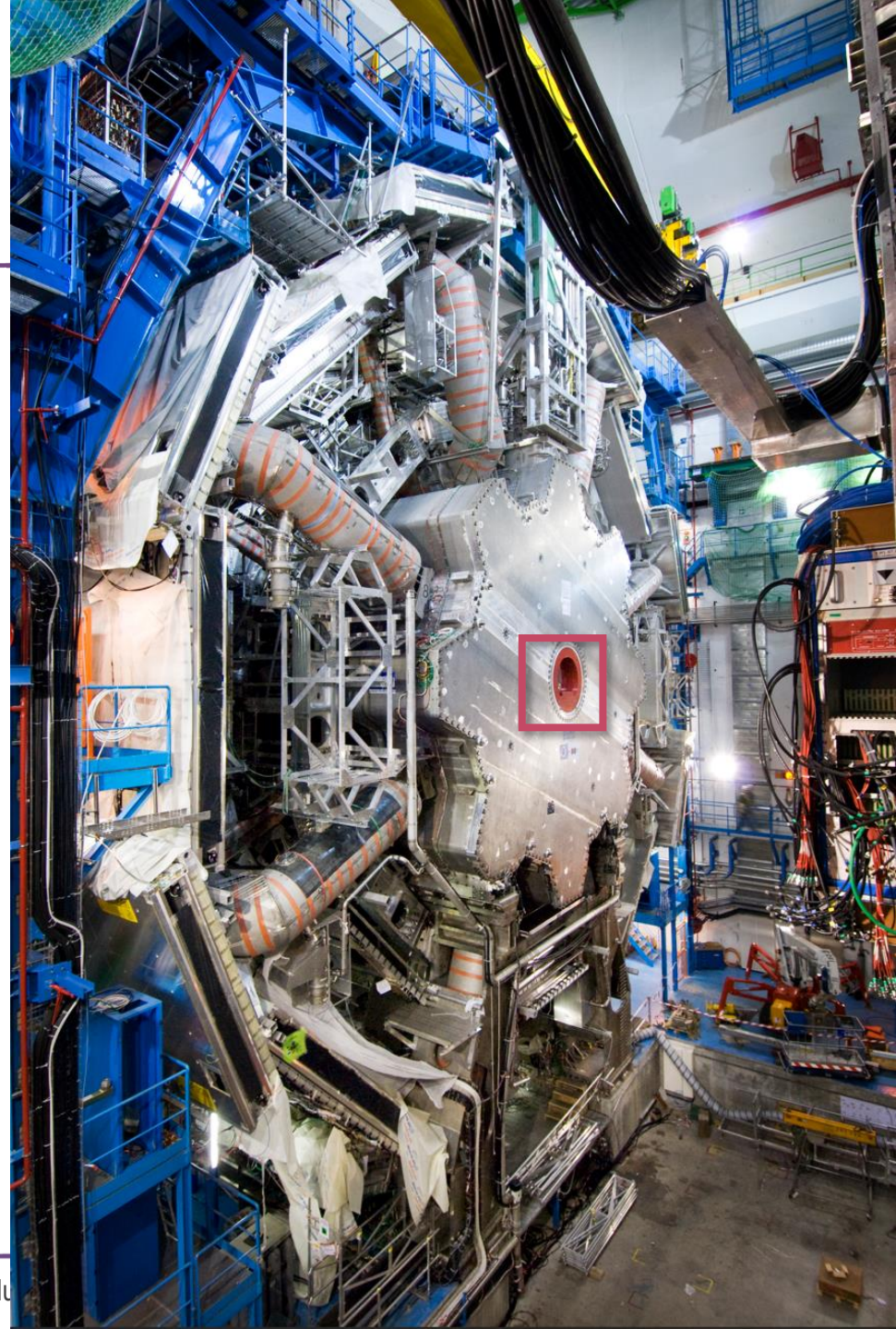
ATLAS – JTT

JT – Toroid Shielding

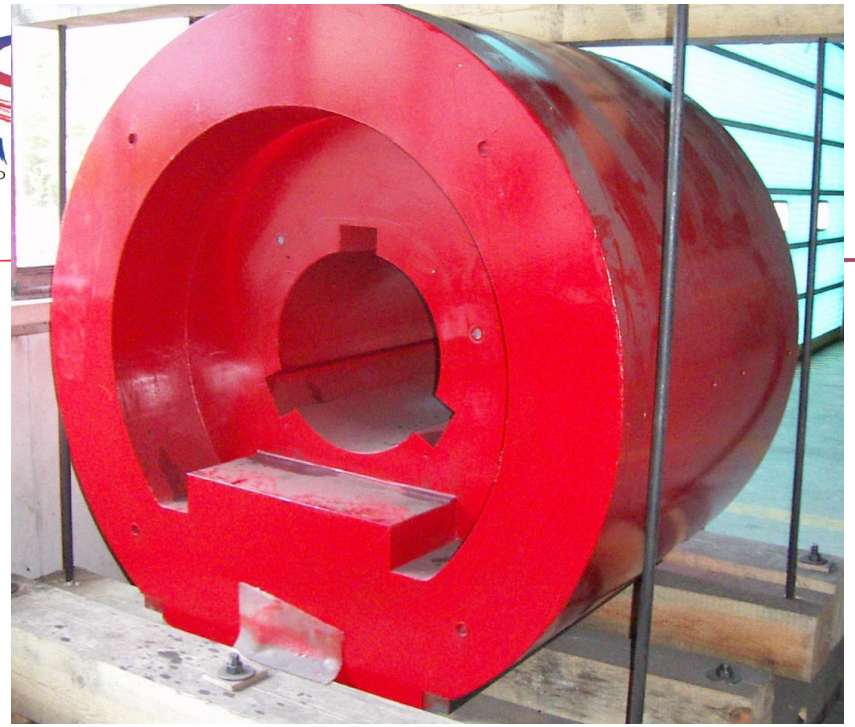
- Ductile cast iron around beam pipe
- Polyethylene layer doped w/ B_2O_3 (5%)
- SS bore tube supporting shielding
- Sits inside the end-cap toroid cryostat

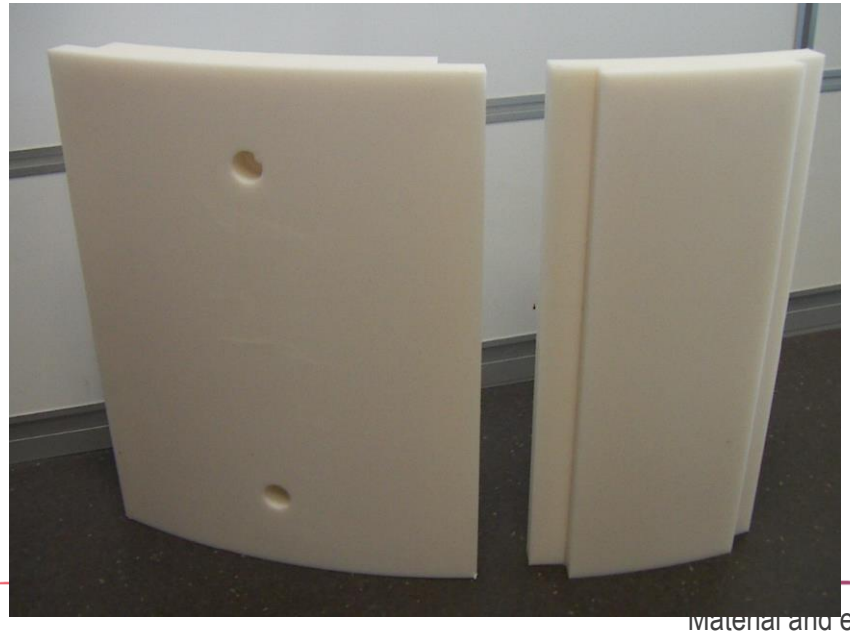


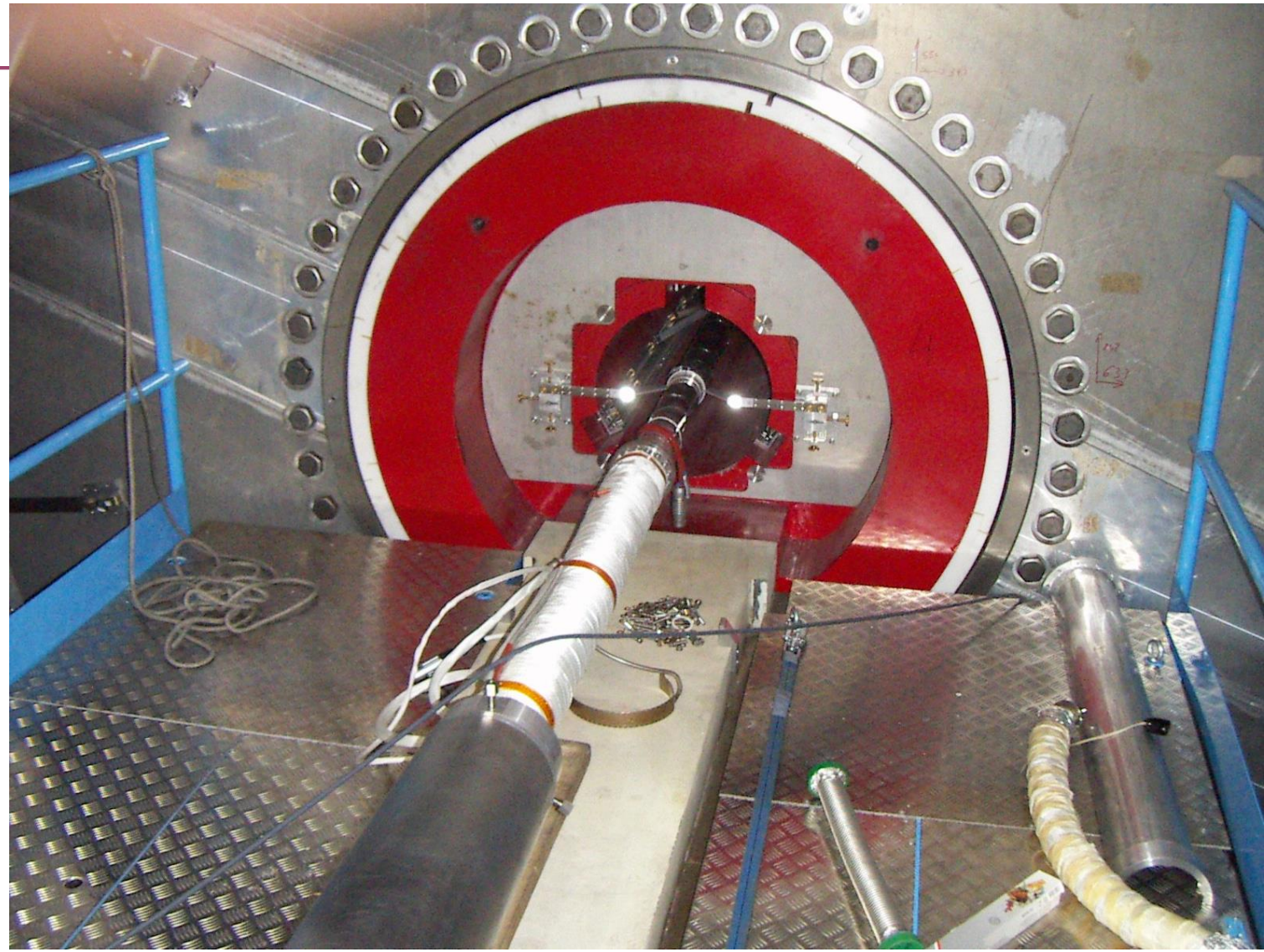


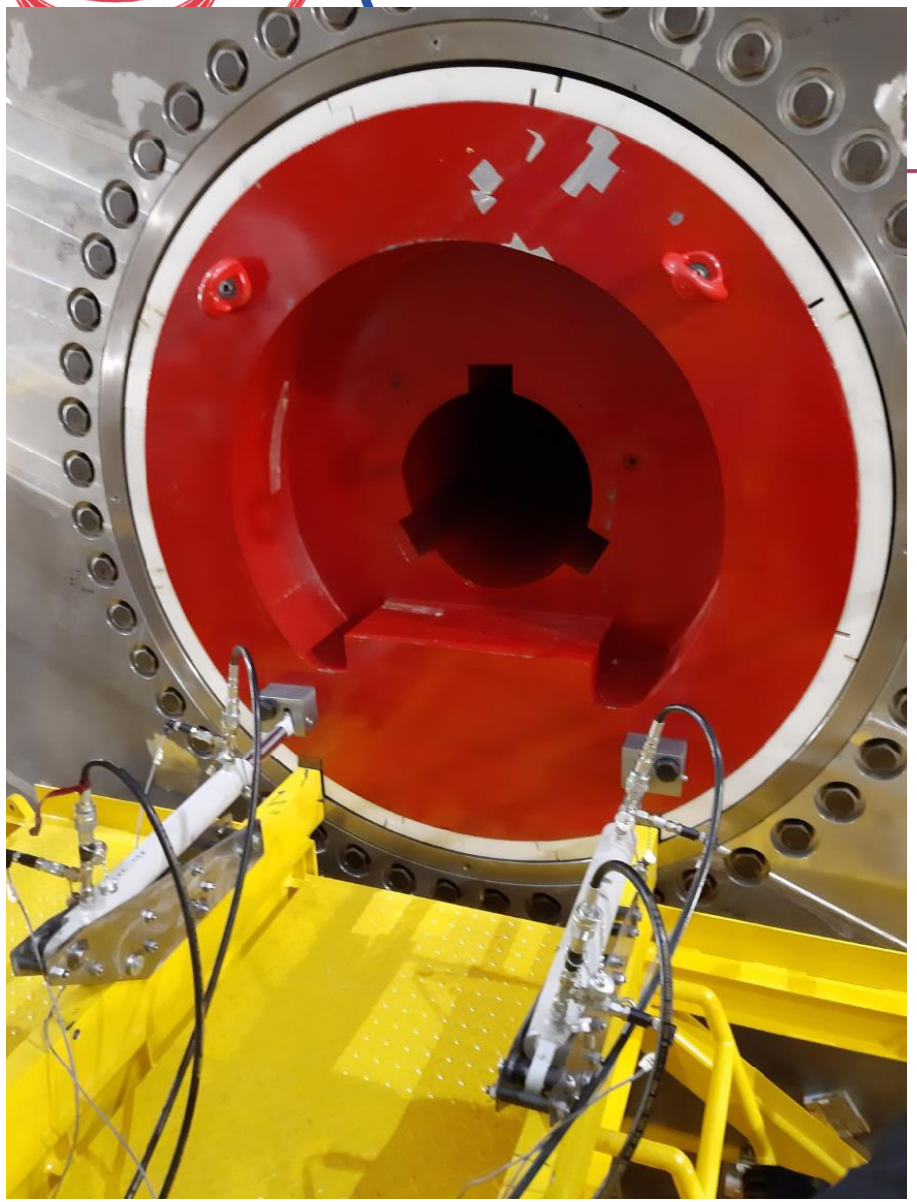


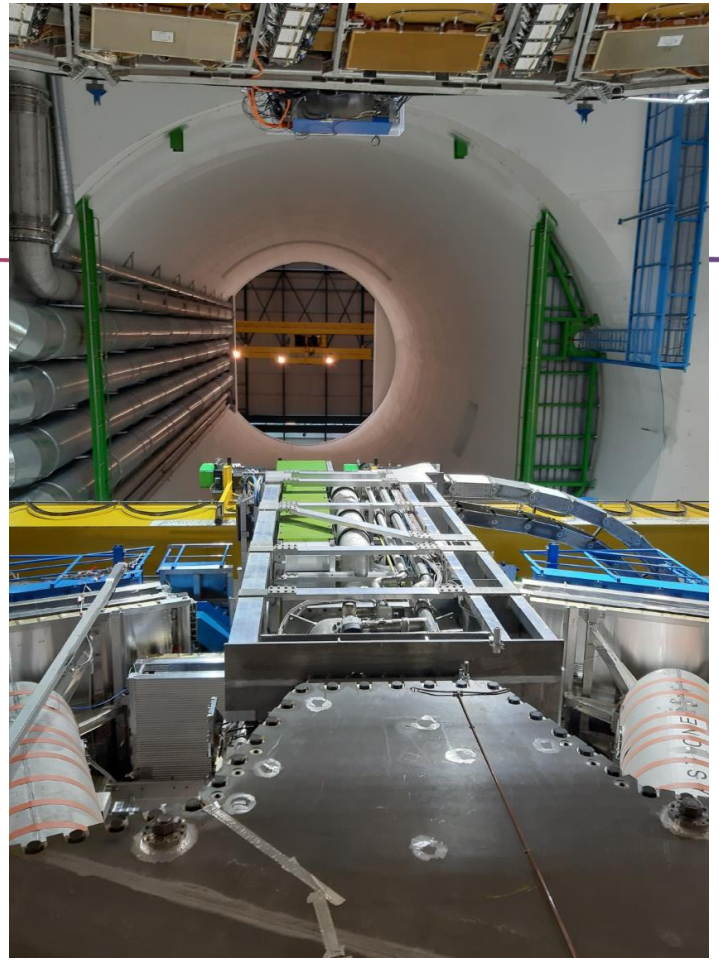
ATLAS – JTT

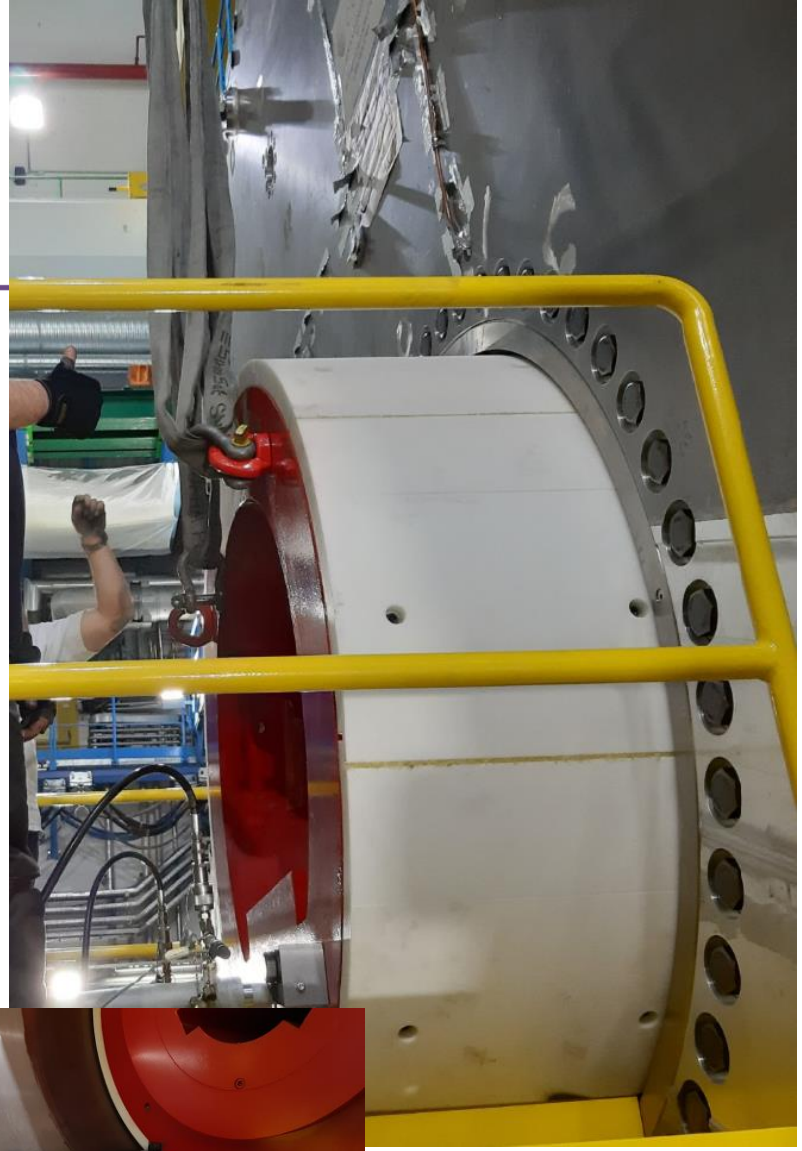


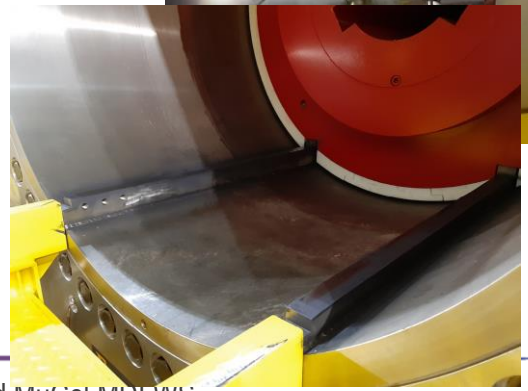










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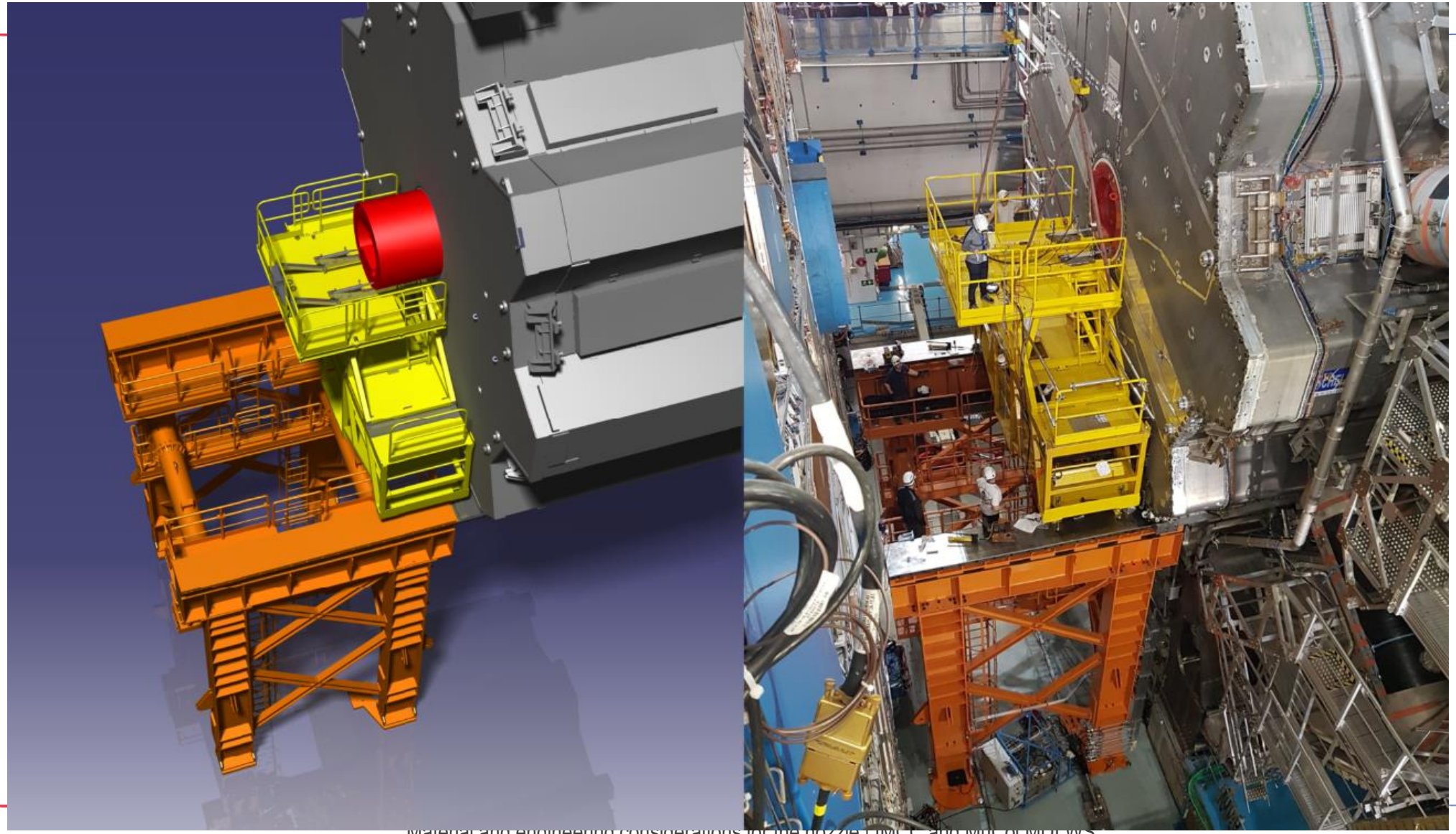
TARE 5000 DAN
CHARGE MAXI 15 T

ATLAS – JTT



IMCC MDI nozzle shielding

(starting from scratch… very first considerations)

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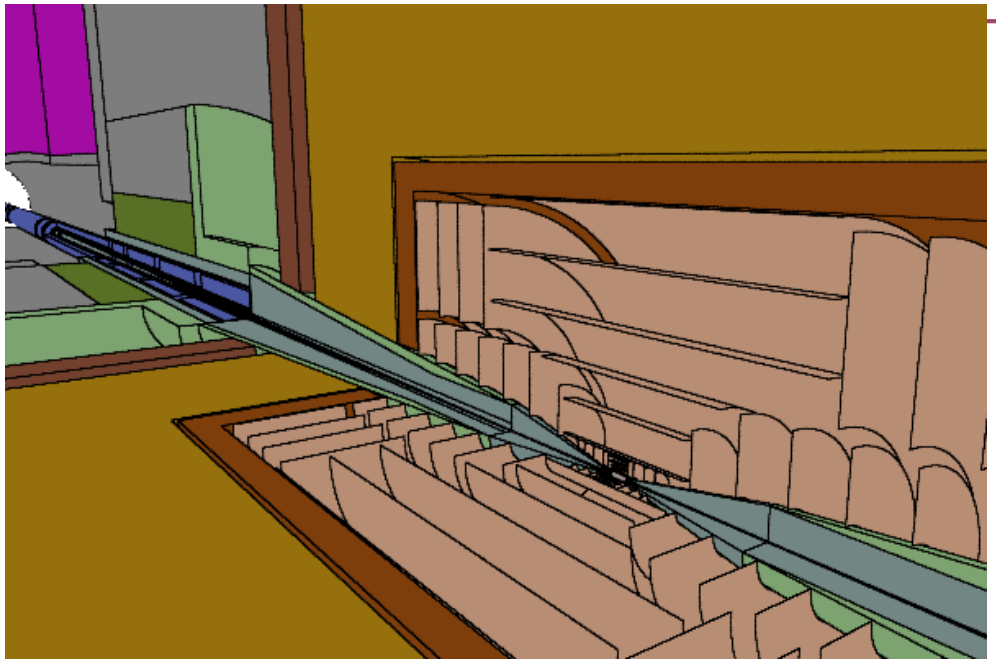
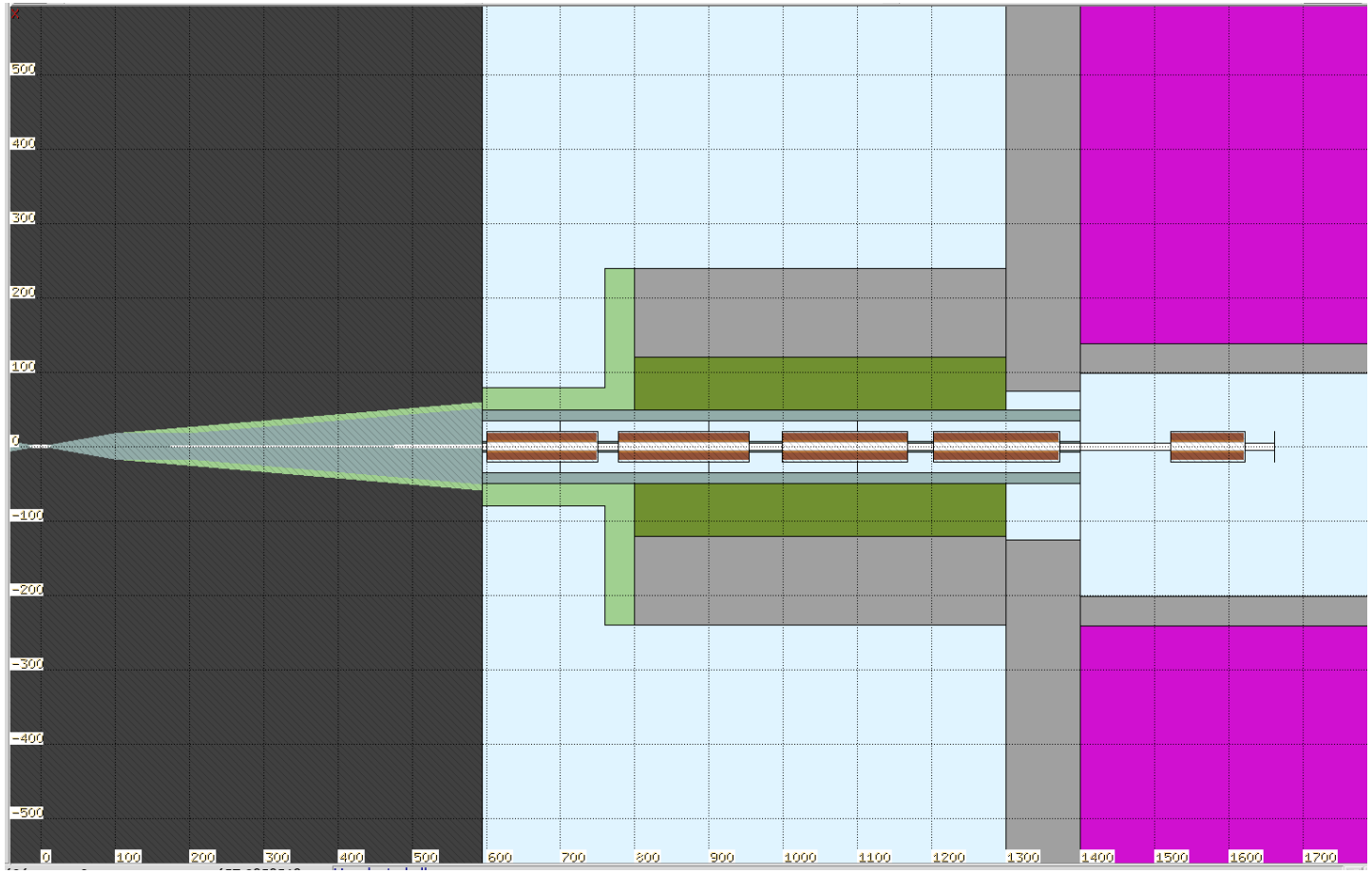
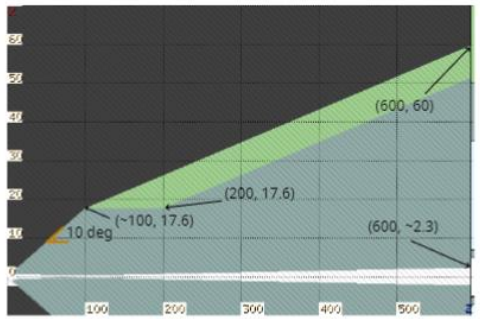
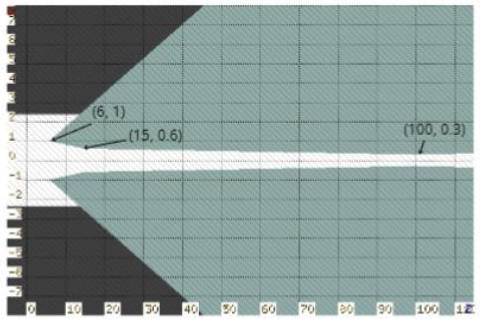
Nozzle shielding





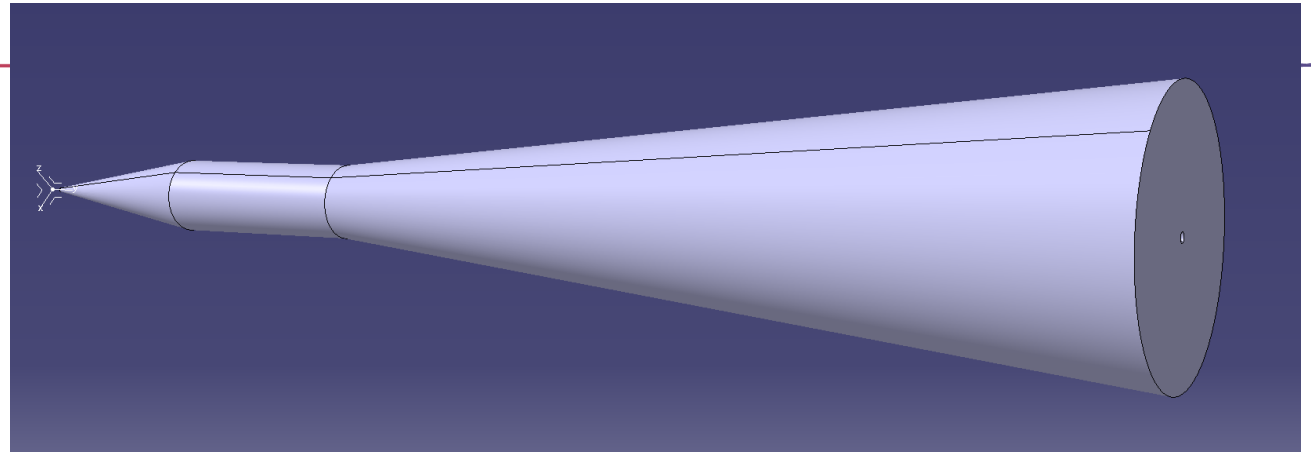


(a) Nozzle shape



(b) Tip details

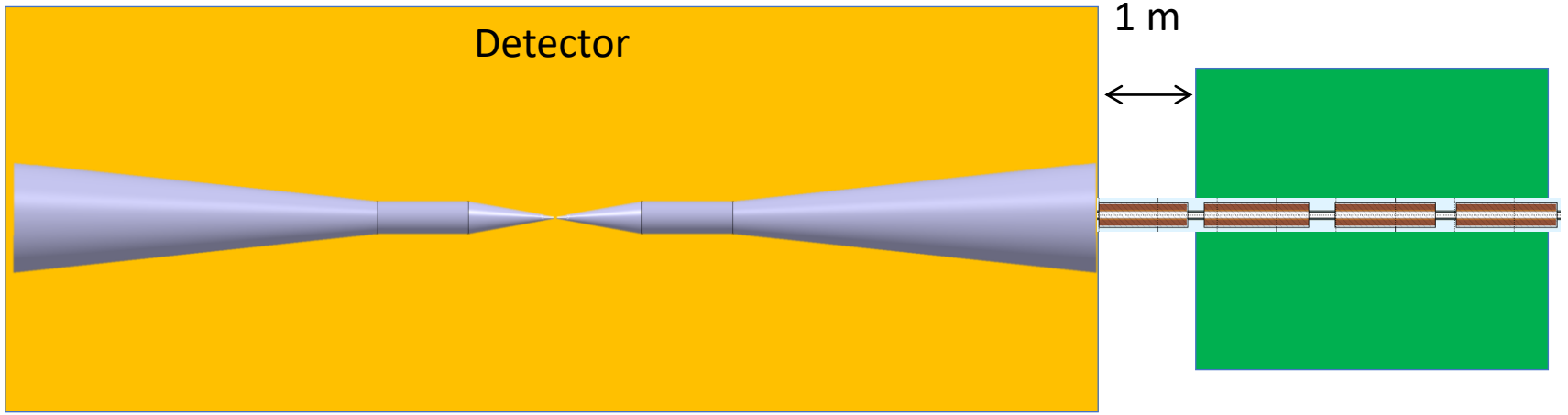
Nozzle shielding



6 m length x 1.2 m max D → ~100 tonnes (considering W)

- Size & shape & weight make it virtually impossible to produce as a single piece
- Likely to be segmented. E.g. inner nozzle as single part + multiple segments on larger cone.
- Material W → unless radiation damage & structural function is a requirement, W-based alloys are suggested. E.g. WHA based on Ni, Cu, Fe allow much better machining and have less size limitations. Possible Pb ?
- Power deposited by the beam in the order of 1-10 kW ? – cooling may be required. May be challenging to cop temperature changes with high precision.
- Dedicated vacuum pipes required.

Nozzle shielding

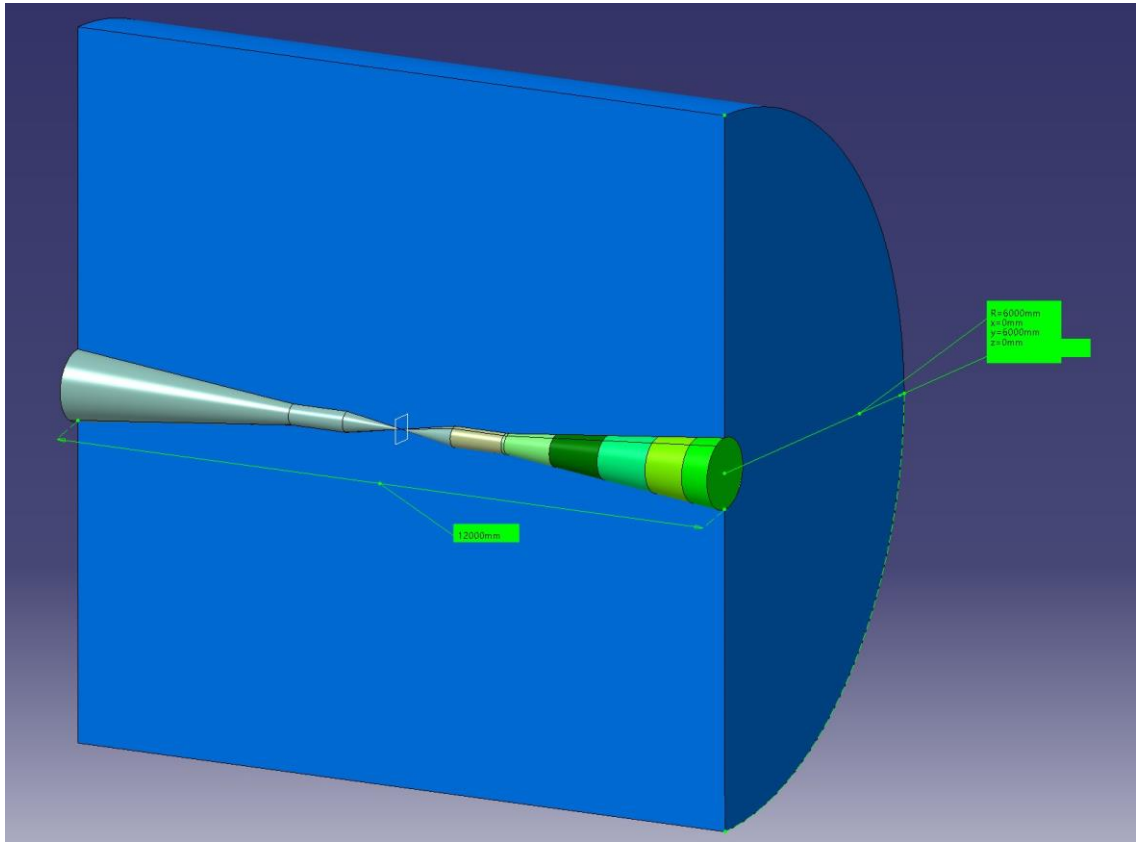


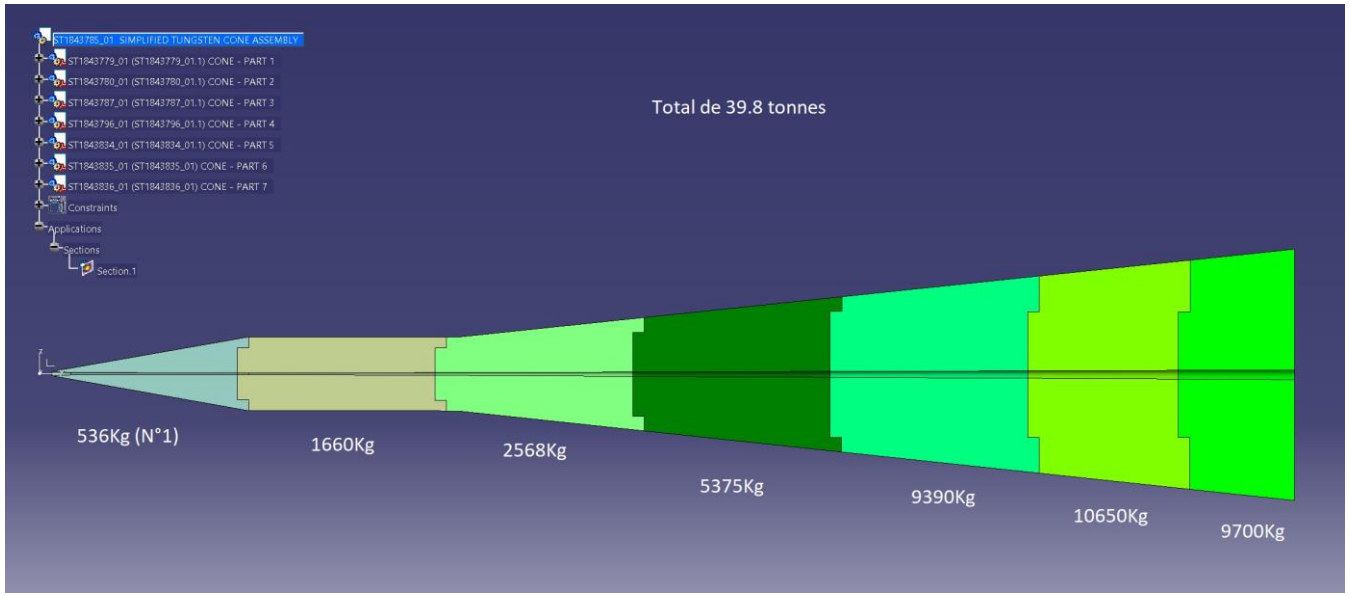
Challenging integration

- Can we open the detector ? E.g. vertical plane ?
- Can the detector assembly structurally support the shielding ? (it must anyway…)
- What is the useful volume / Gap between Detector and upstream beamline which one shall use for the supporting structure? 1 m ? We may need to dismantle it to access shielding
- Vacuum beam pipe integration along the detector. What tolerances/alignment precision?
- Etc..

Nozzle shielding

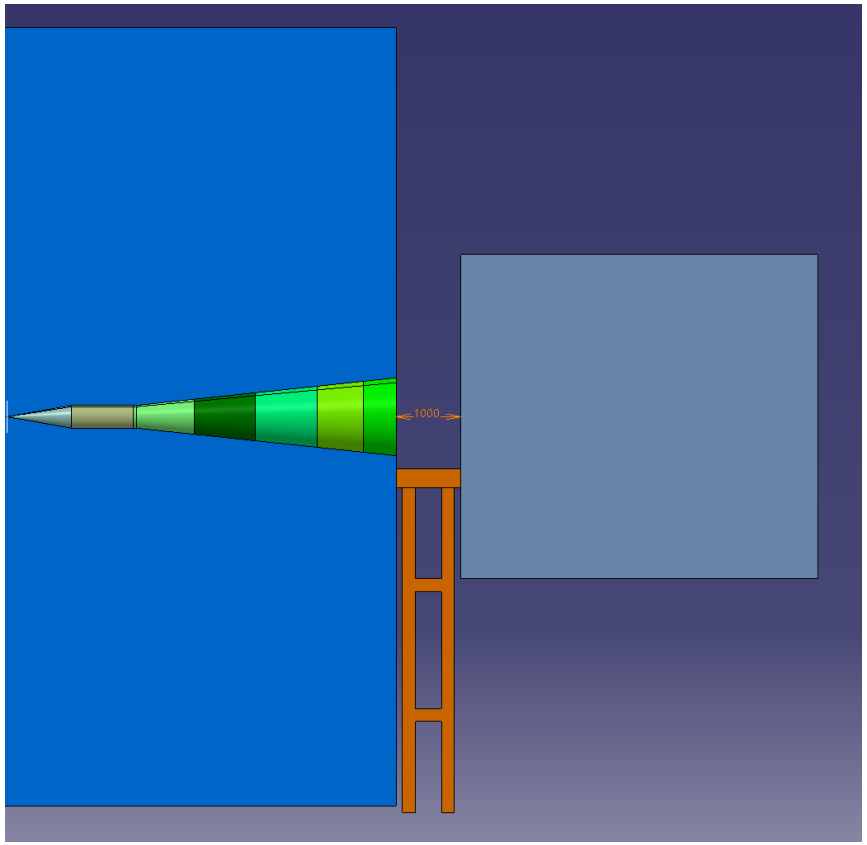
- Handling limitations. Segmentation

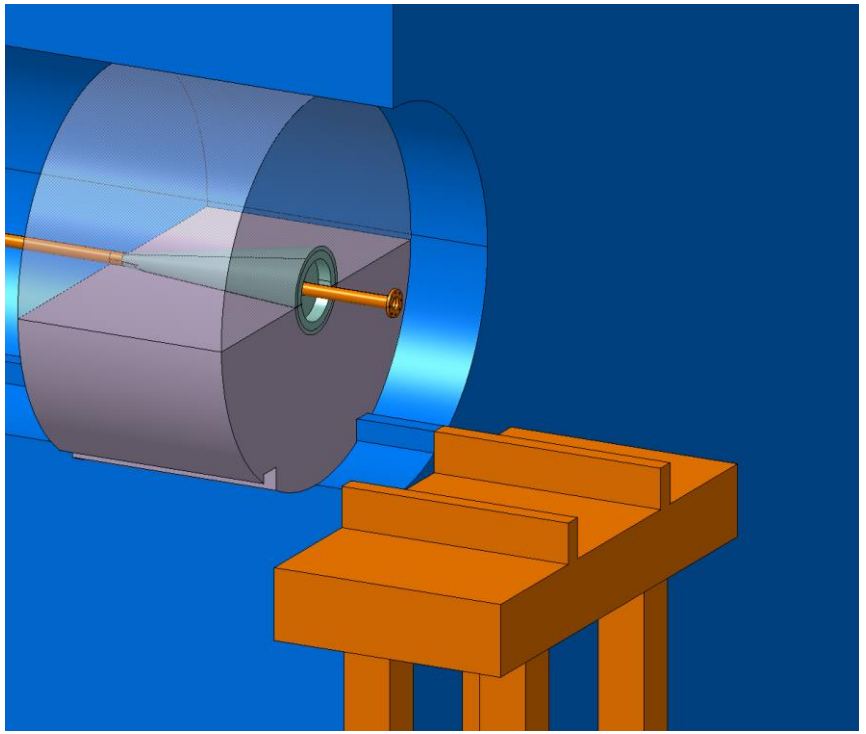


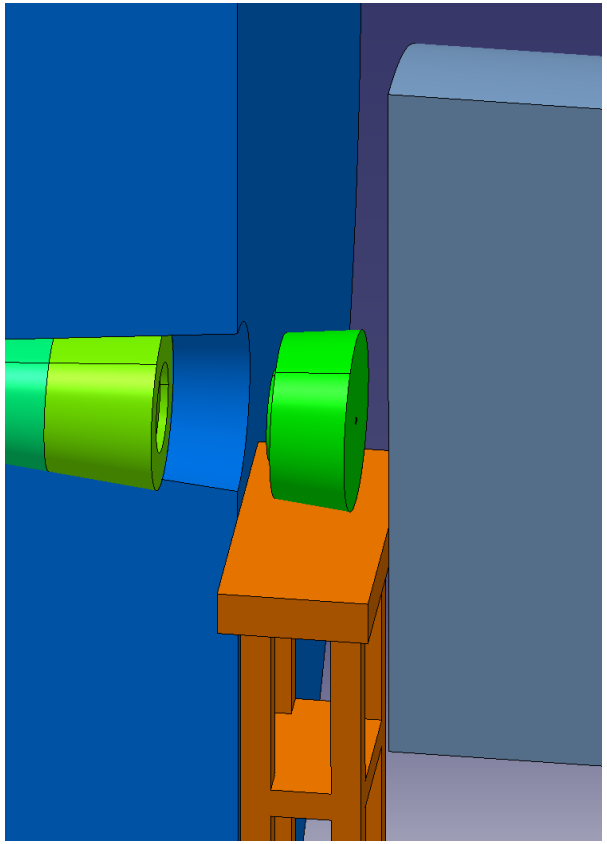


Nozzle shielding

- Access for handling

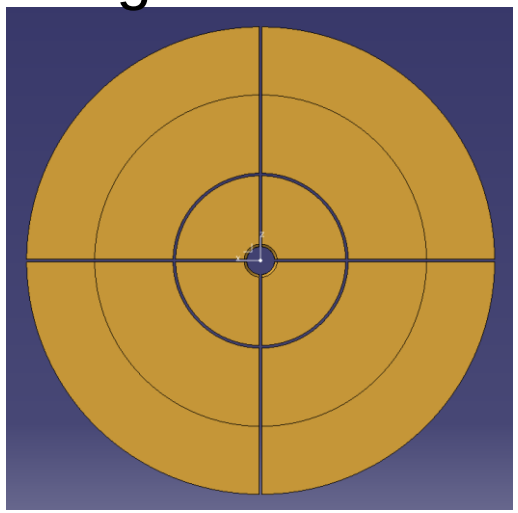
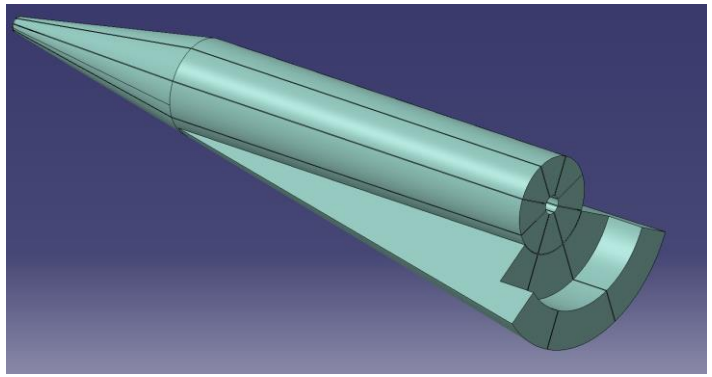
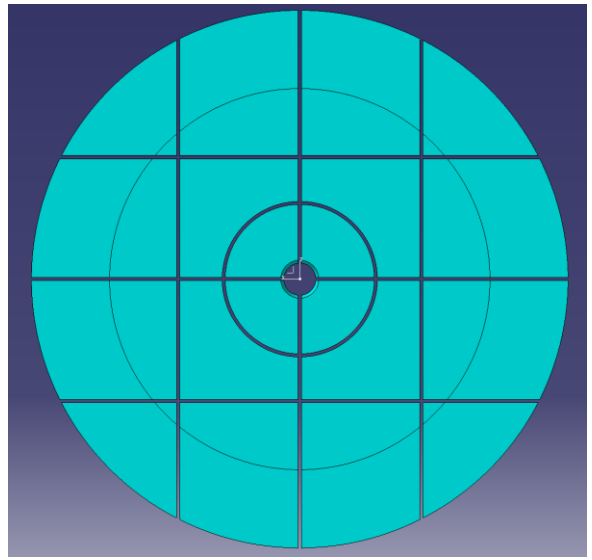
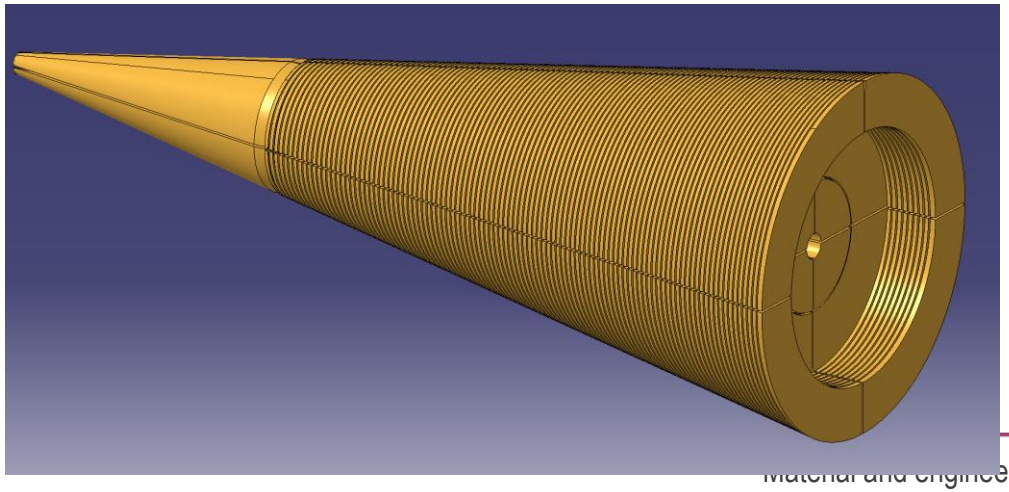
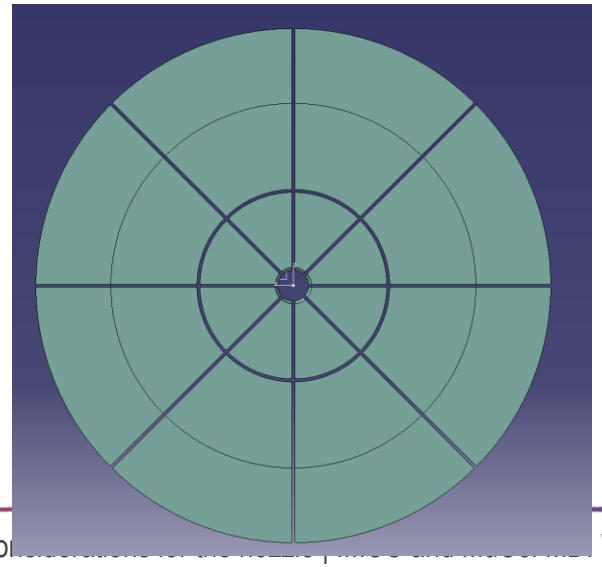
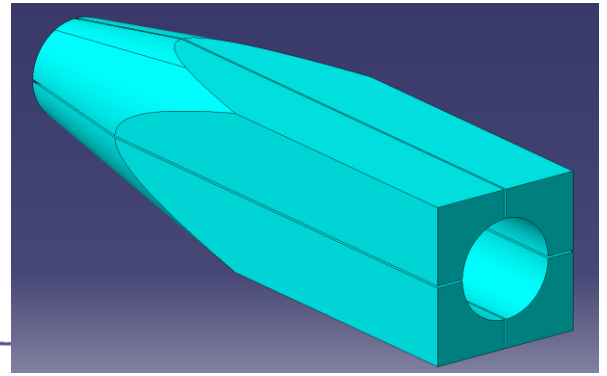






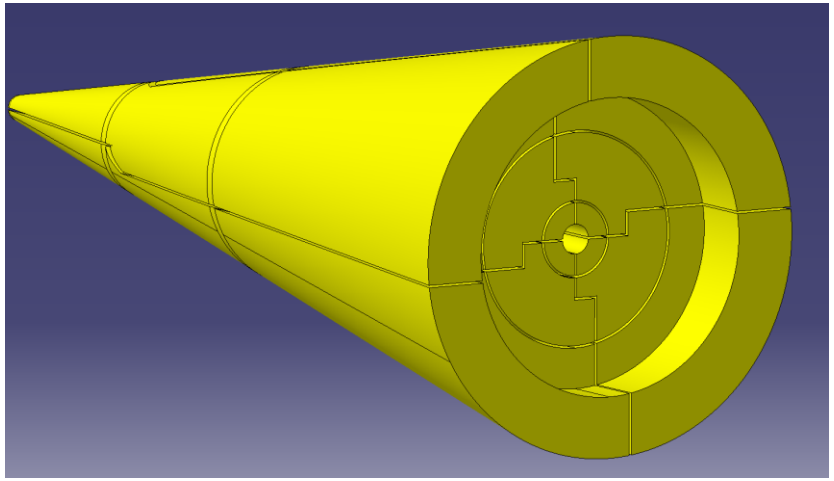
Nozzle shielding

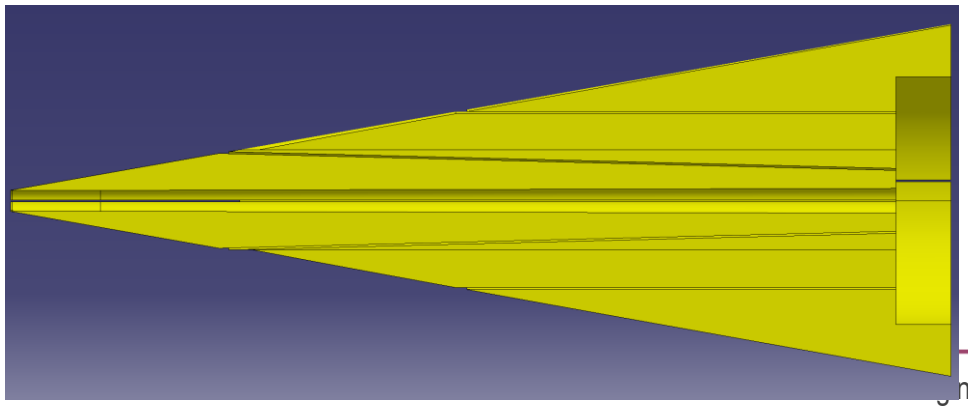
- Tungsten-made nozzle shape may impose special assembly configurations

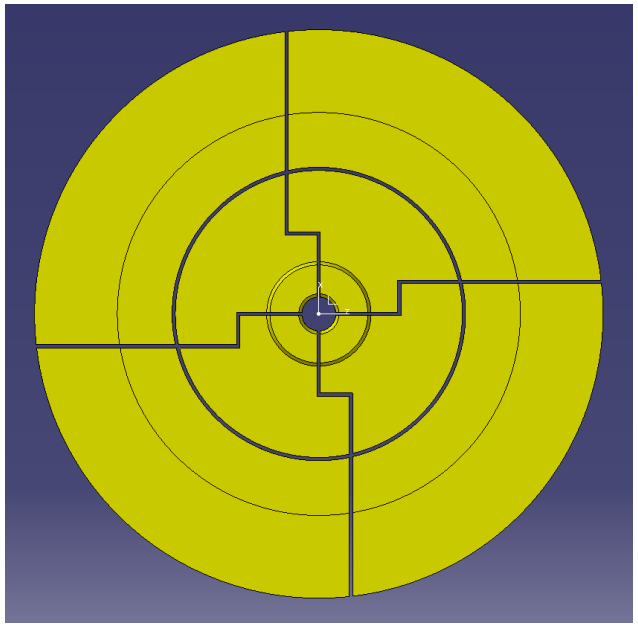







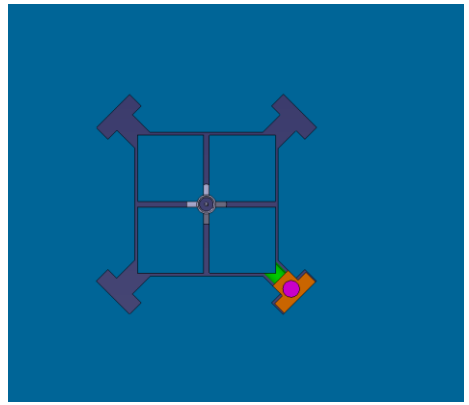
Nozzle shielding

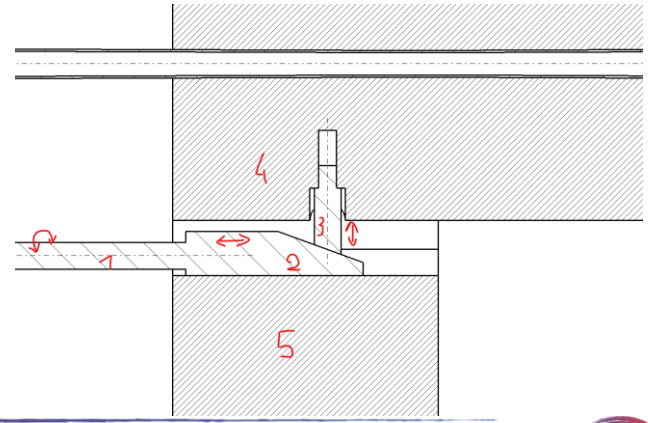
- Position/tolerance/alignment requirements need to be defined and translated to an engineering design (even if conceptual)











Conclusions

- Solid experience in existing experiments. We shall investigate/collaborate to check what we can learn from other facilities (e.g. ATLAS, SuperKEKB Belle II, etc)
- Currently starting a high-level breakdown to identify main challenges/constrains on the engineering side
- High-level conceptualization of nozzle shielding ongoing.
- In the coming months, the goal is to iterate with the Daniele/Anton's team to adapt nozzle shielding according to engineering considerations

Many thanks!

Funded by
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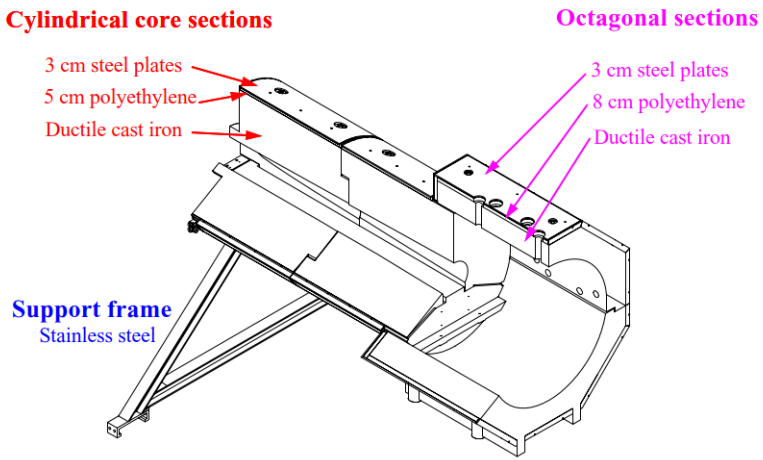
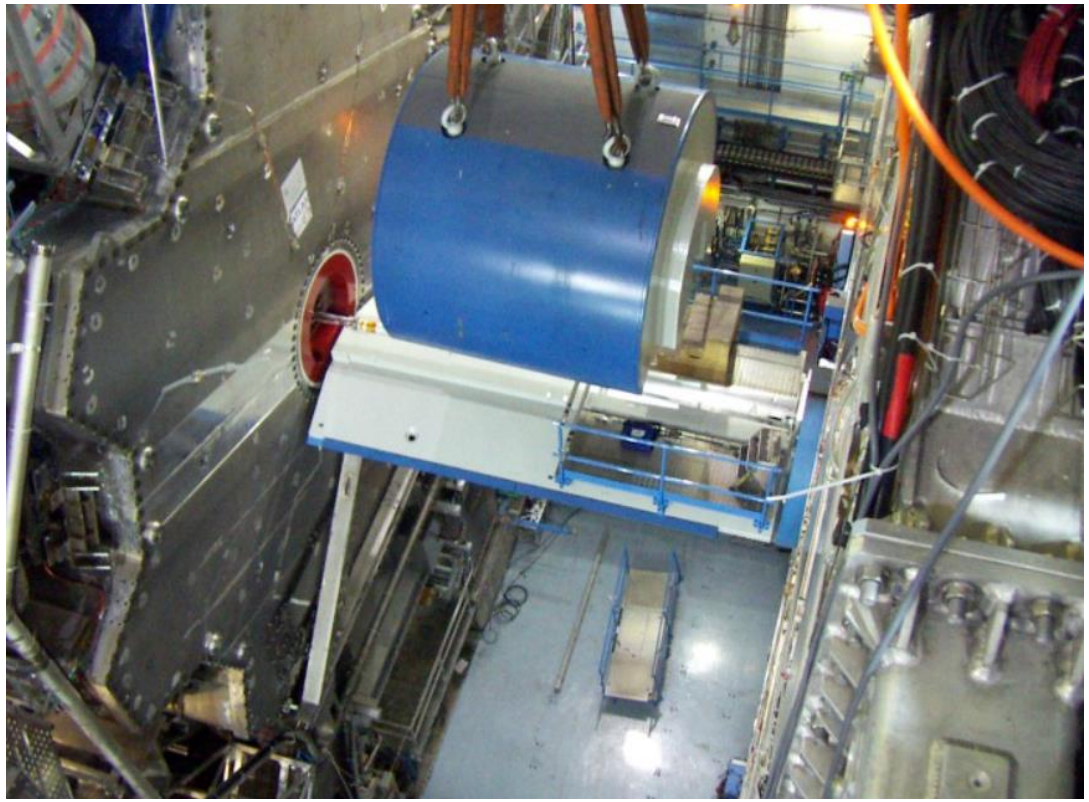
Funded by the European Union (EU).Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the EU or European Research Executive Agency (REA). Neither the EU nor the REA can be held responsible for them.

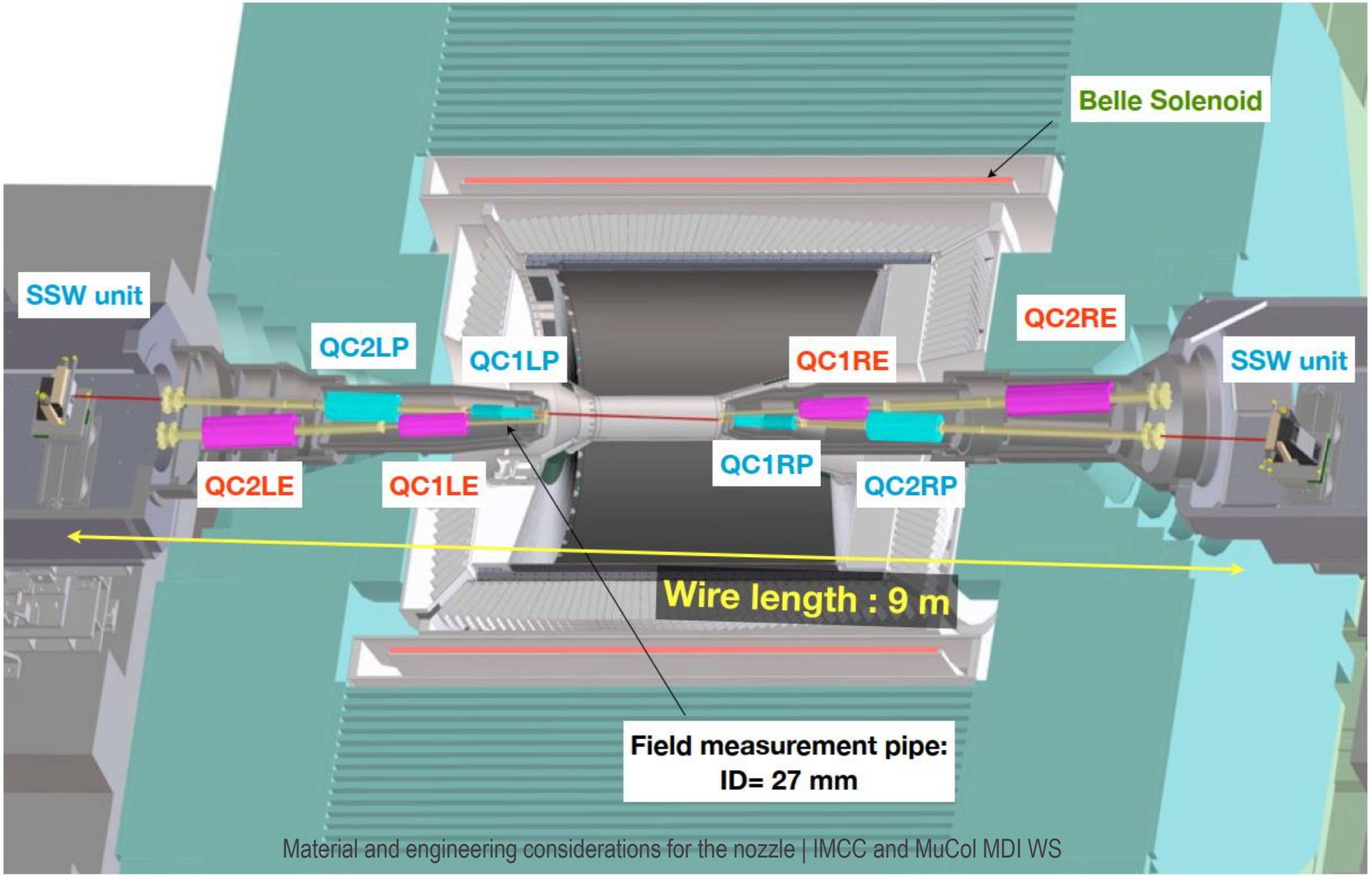
ATLAS - JF

- **JT – Forward Shielding**
- Protect mid and outer end-cap muon stations from background of secondaries produced in the beam pipe, calorimeters and TAS.
- Ductile cast iron around beam pipe
- 5-8cm Polyethylene layer doped w/ H_3BO_3 (10k bricks)
- 3 cm steel

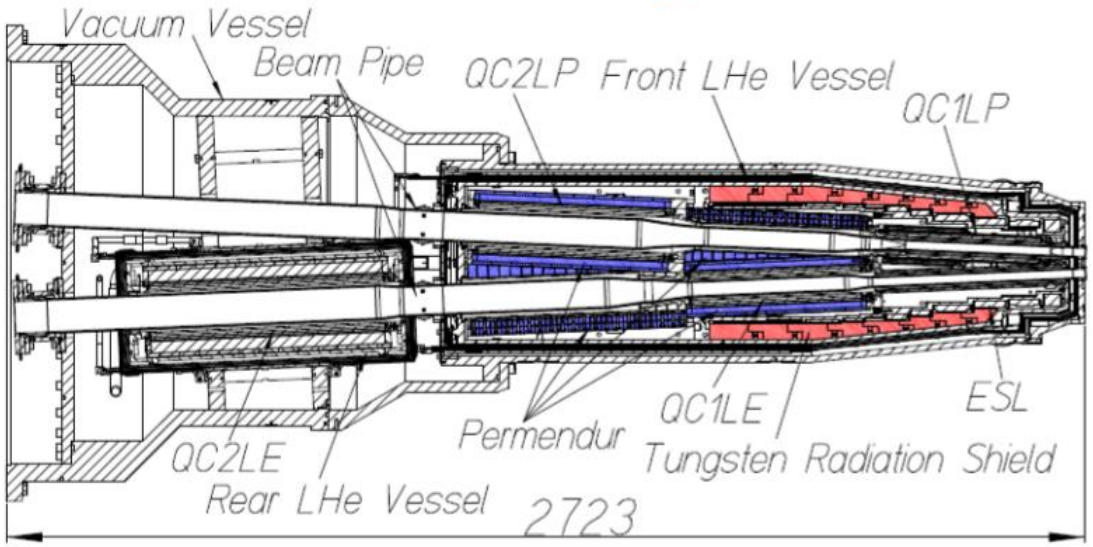
e) Forward shielding






Belle Solenoid
SSW unit
QC2LP
QC1LP
QC1RE
QC2RE
SSW unit
QC2LE
QC1LE
QC1RP
QC2RP
Wire length : 9 m
Field measurement pipe:
ID= 27 mm

QCS-L cryostat



QCS-R cryostat