PANDA Solenoid Design Progress

Andrea Bersani

INFN Sezione di Genova

Summary

Summary

- Cryogenic chimney design
  - Including requested modifications

Summary

- Cryogenic chimney design
  - Including requested modifications
- Cool down scenarios
  - Procedure definition and time estimation

Summary

- Cryogenic chimney design
  - Including requested modifications
- Cool down scenarios
  - Procedure definition and time estimation
- Cable joints loss
  - Cable welding technique choice

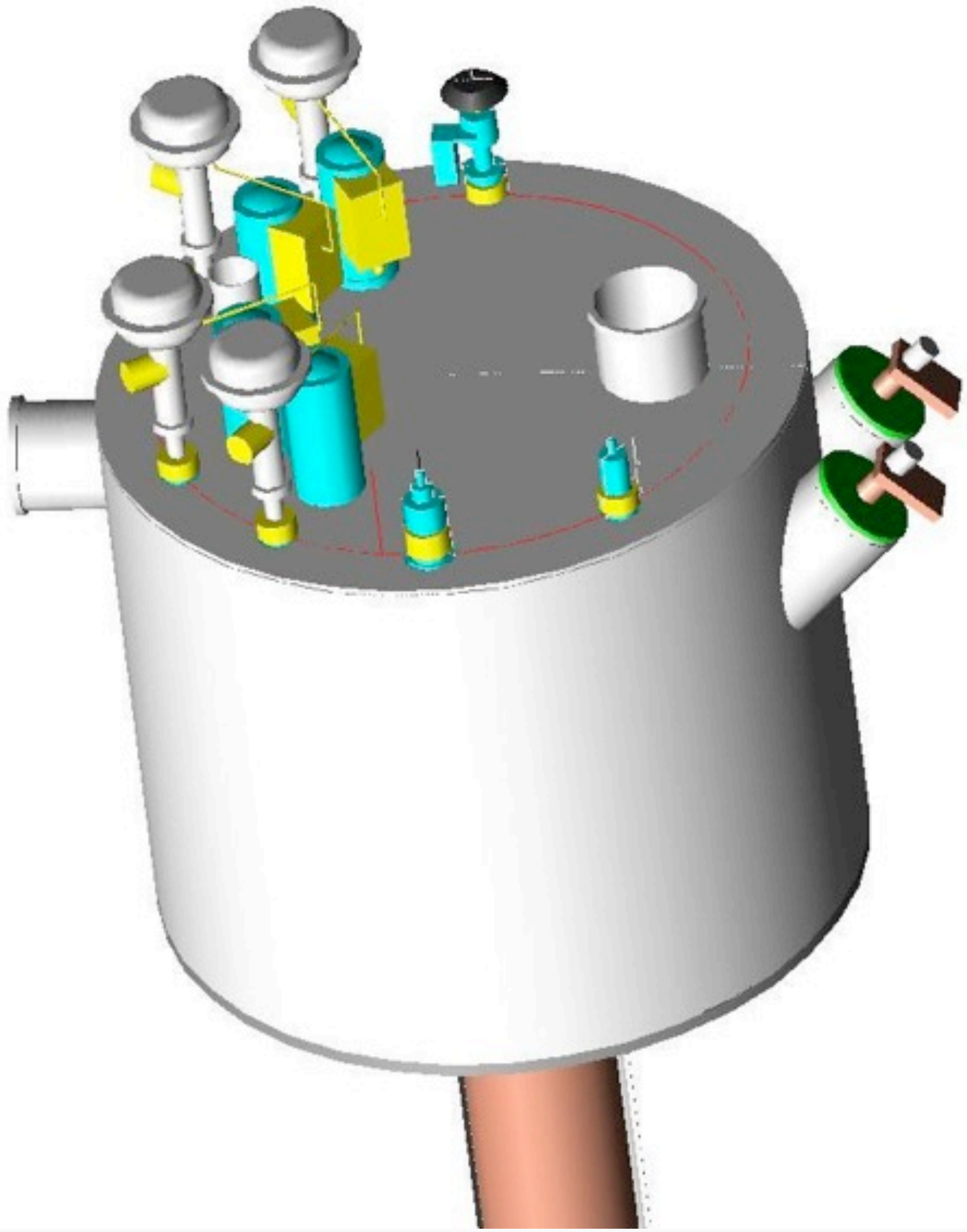
Summary

- Cryogenic chimney design
  - Including requested modifications
- Cool down scenarios
  - Procedure definition and time estimation
- Cable joints loss
  - Cable welding technique choice
- New thermal simulations
  - Comparison between different codes

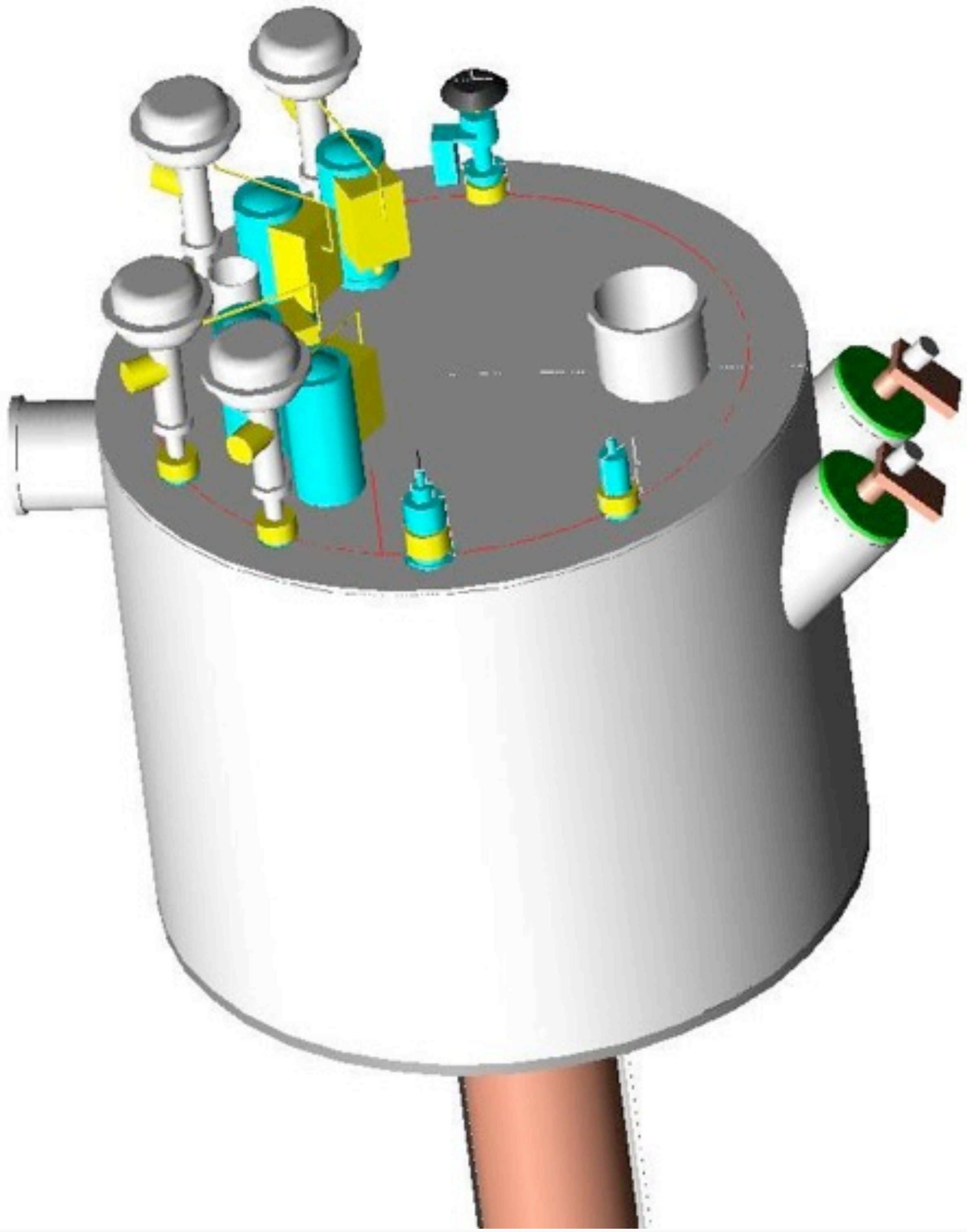
Summary

- Cryogenic chimney design
  - Including requested modifications
- Cool down scenarios
  - Procedure definition and time estimation
- Cable joints loss
  - Cable welding technique choice
- New thermal simulations
  - Comparison between different codes
- Open questions
  - Yes, we have

The Cryogenic Chimney

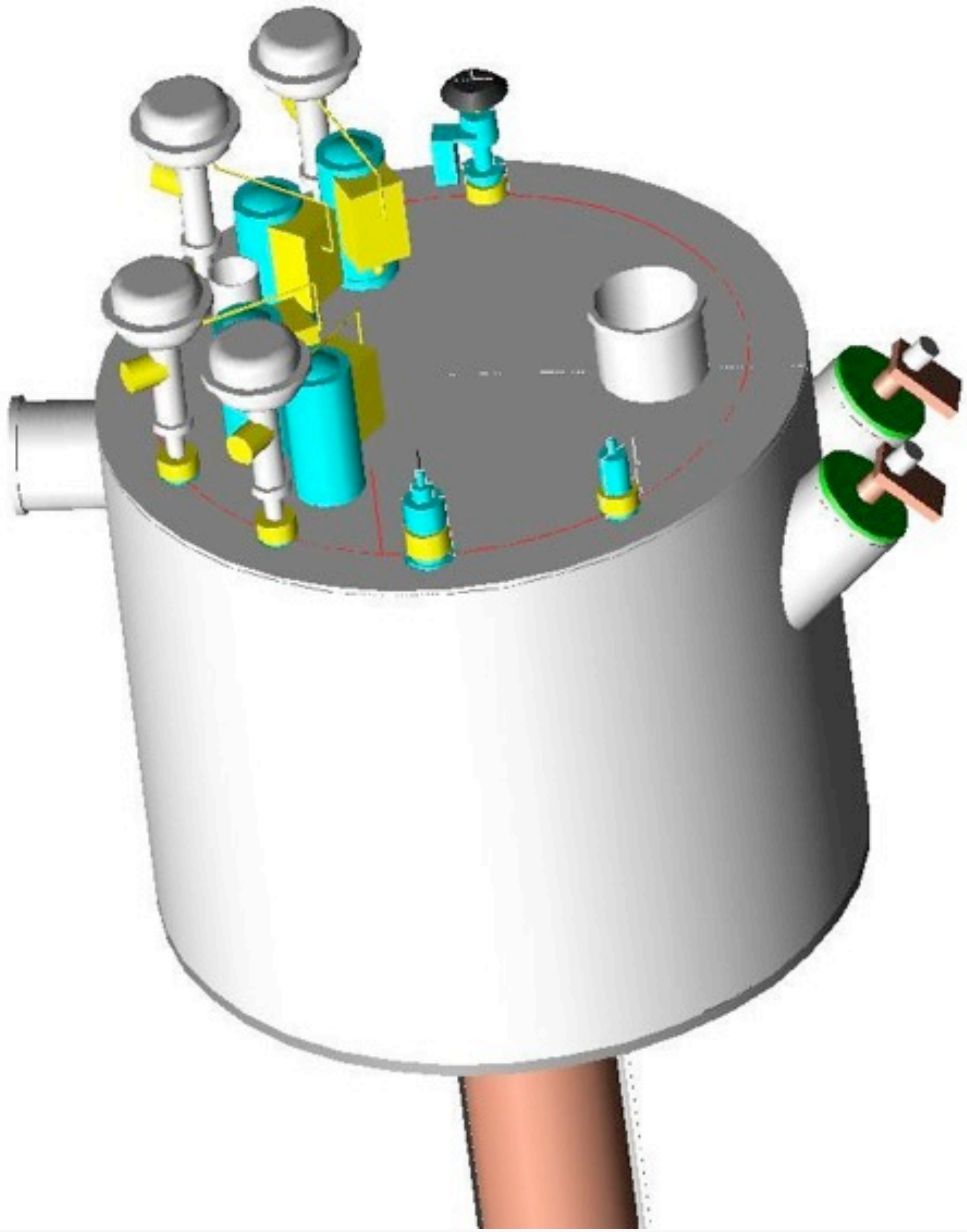


The Cryogenic Chimney



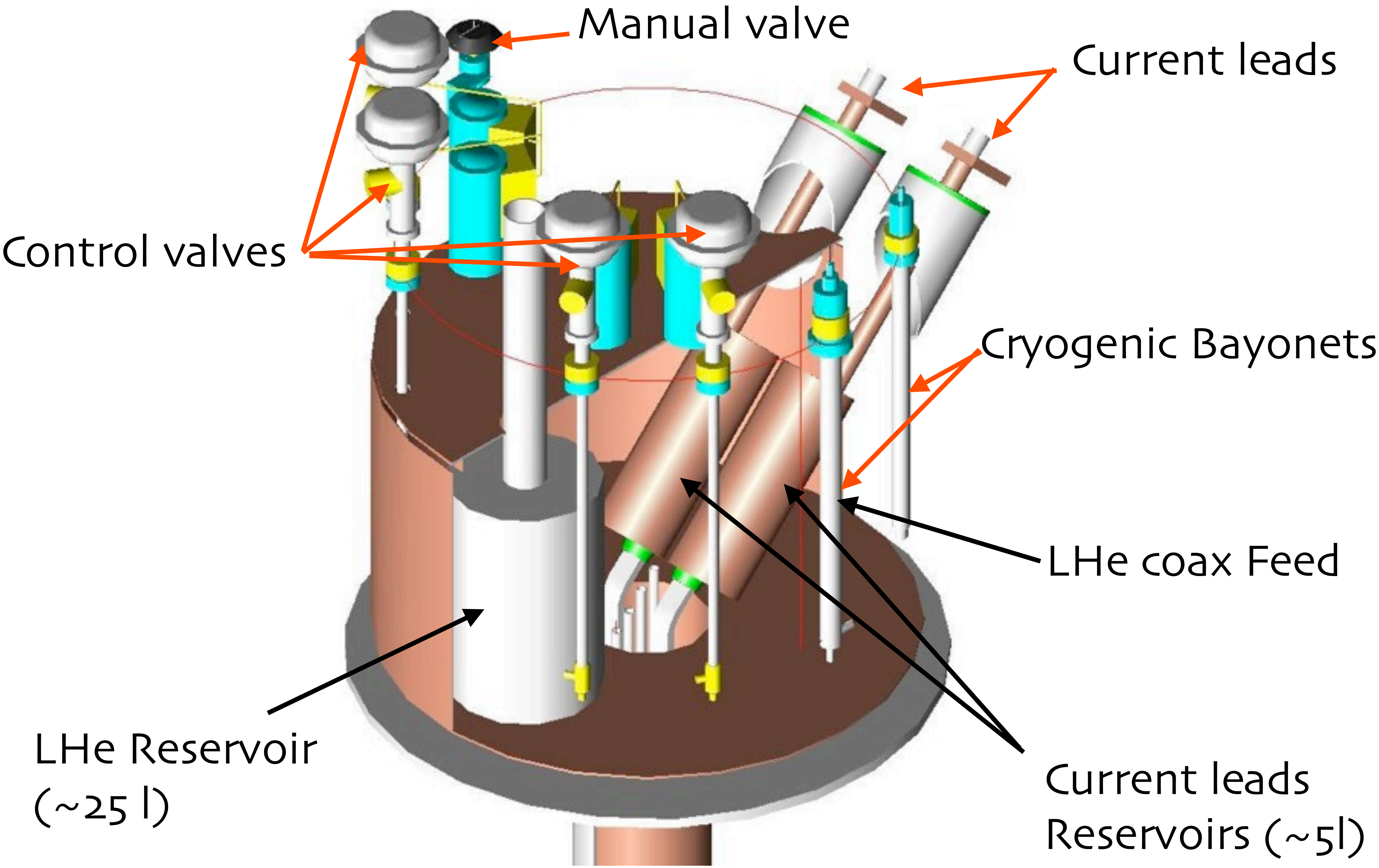
- The flanges for two turbo pumps are foreseen

The Cryogenic Chimney



- The flanges for two turbo pumps are foreseen
- The design is based on BaBar and Atlas ones

The Control Dewar



Circuitry Components

Circuitry Components

- Possible providers has been identified and realistic components are included in the model

Circuitry Components

- Possible providers has been identified and realistic components are included in the model
- The current leads are AMI 5KA commercial counterflow current leads

Circuitry Components

- Possible providers has been identified and realistic components are included in the model
- The current leads are AMI 5KA commercial counterflow current leads
- The control valves, manual valve and cryogenic bayonets are from Cryocomp

Circuitry Components

- Possible providers has been identified and realistic components are included in the model
- The current leads are AMI 5KA commercial counterflow current leads
- The control valves, manual valve and cryogenic bayonets are from Cryocomp
- In the cut out the the super-insulation is not shown, anyhow the space for it is foreseen

Circuitry Components

- Possible providers has been identified and realistic components are included in the model
- The current leads are AMI 5KA commercial counterflow current leads
- The control valves, manual valve and cryogenic bayonets are from Cryocomp
- In the cut out the the super-insulation is not shown, anyhow the space for it is foreseen
- Estimation of the total cryogenic losses confirmed the reference values quoted in the TDR

Cryogenic Chimney Integration

Cryogenic Chimney Integration

- An increase of the Cryogenic Chimney length has been requested in two times

Cryogenic Chimney Integration

- An increase of the Cryogenic Chimney length has been requested in two times
- The distance between the cryostat and the control Dewar has been increased by 550 mm

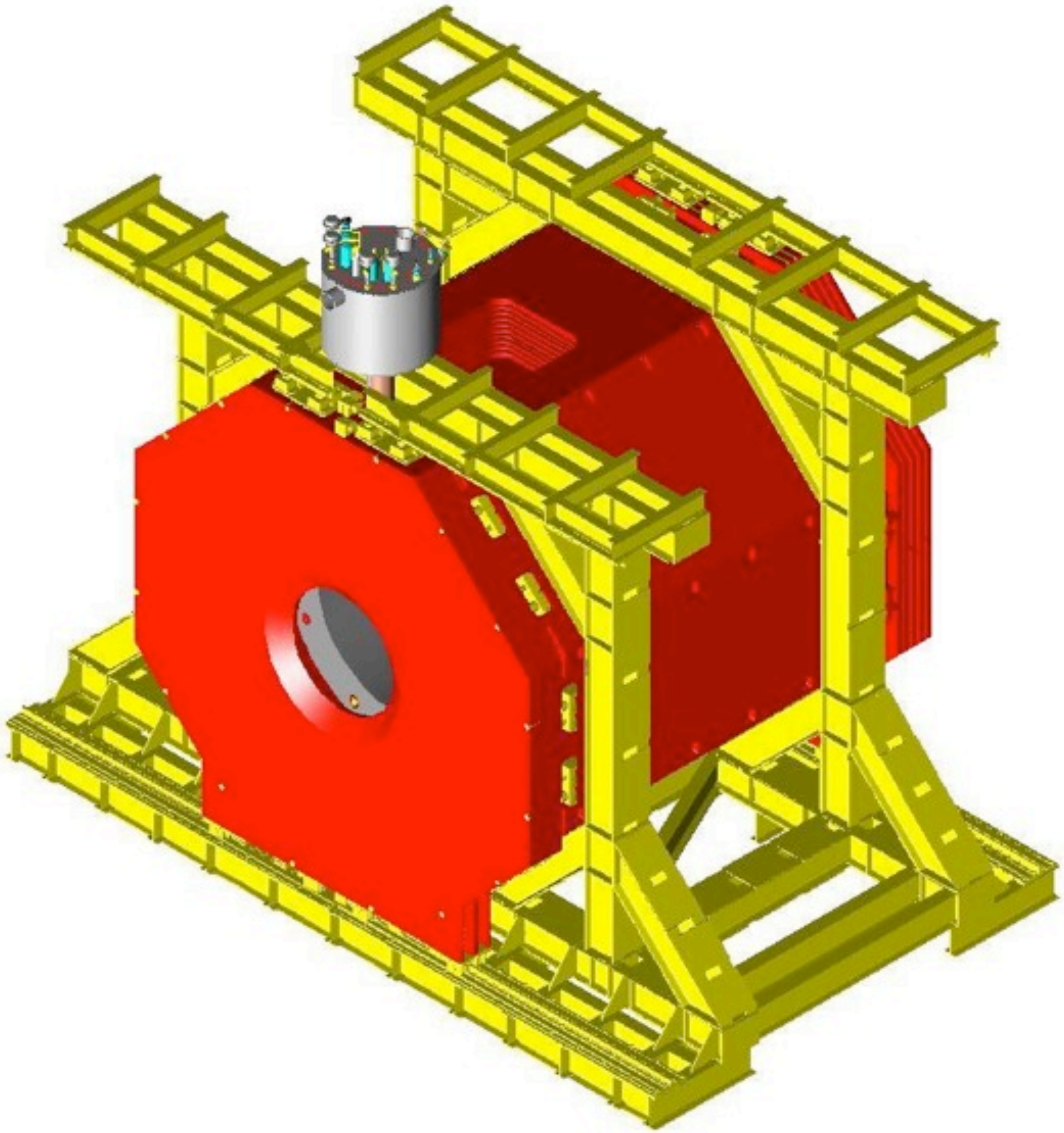
Cryogenic Chimney Integration

- An increase of the Cryogenic Chimney length has been requested in two times
- The distance between the cryostat and the control Dewar has been increased by 550 mm
- This should allow safe operations for the upstream doors and allow all the needed clearance for the upper support beams

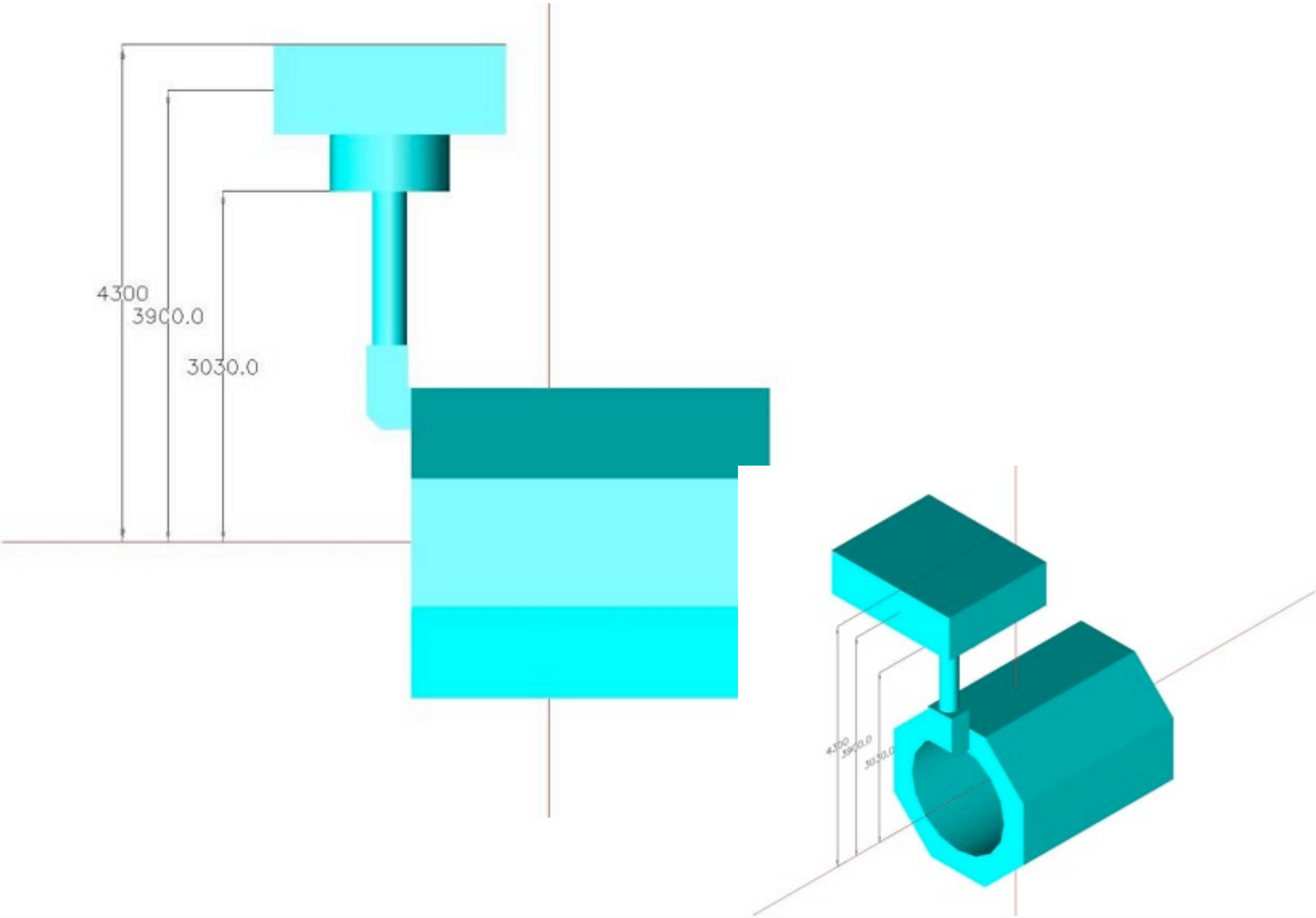
Cryogenic Chimney Integration

- An increase of the Cryogenic Chimney length has been requested in two times
- The distance between the cryostat and the control Dewar has been increased by 550 mm
- This should allow safe operations for the upstream doors and allow all the needed clearance for the upper support beams
- At the moment, all the conflicts have been removed and the cryostat model fits the yoke model as it is in the WIKI

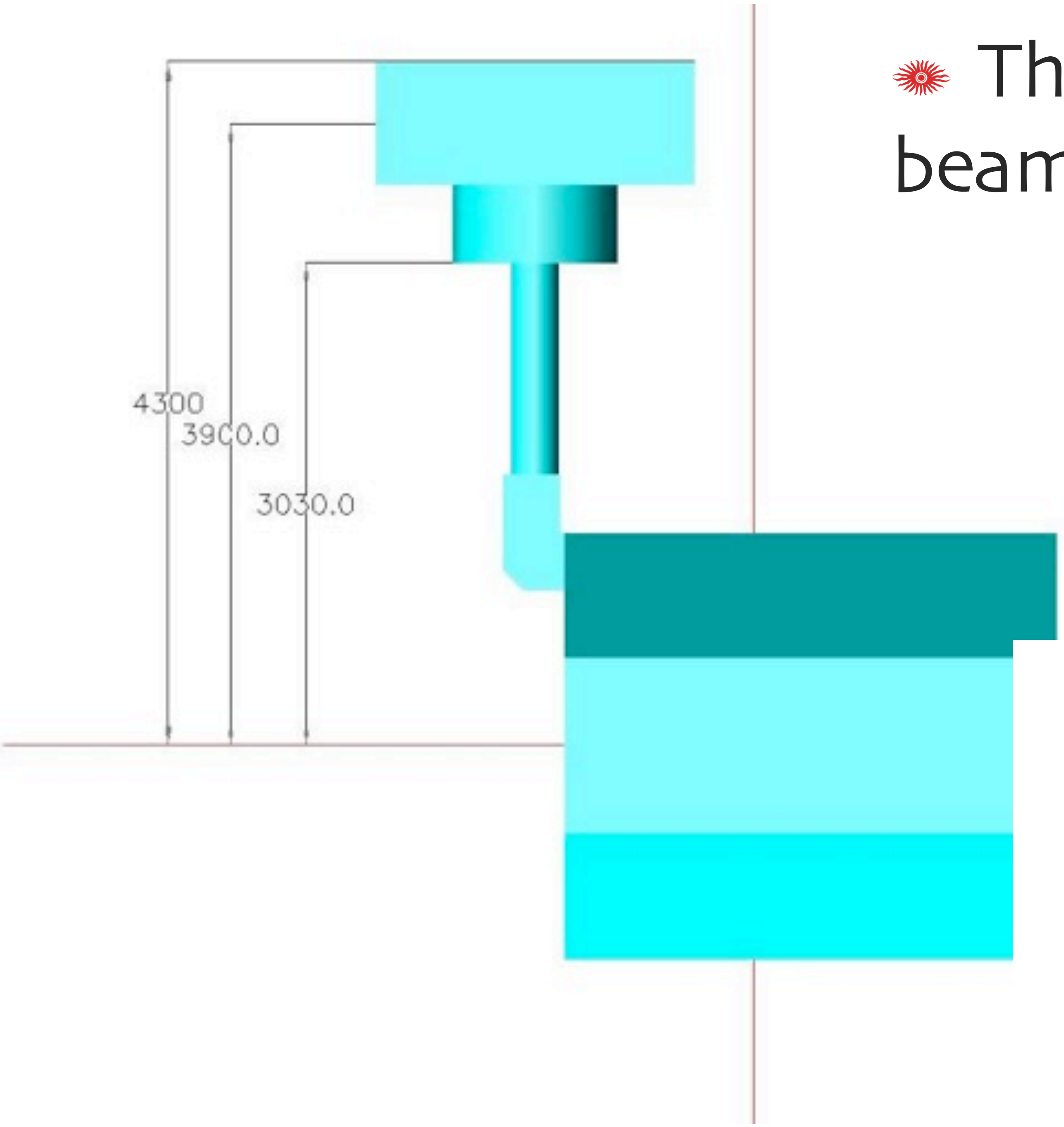
PANDA TS Overview



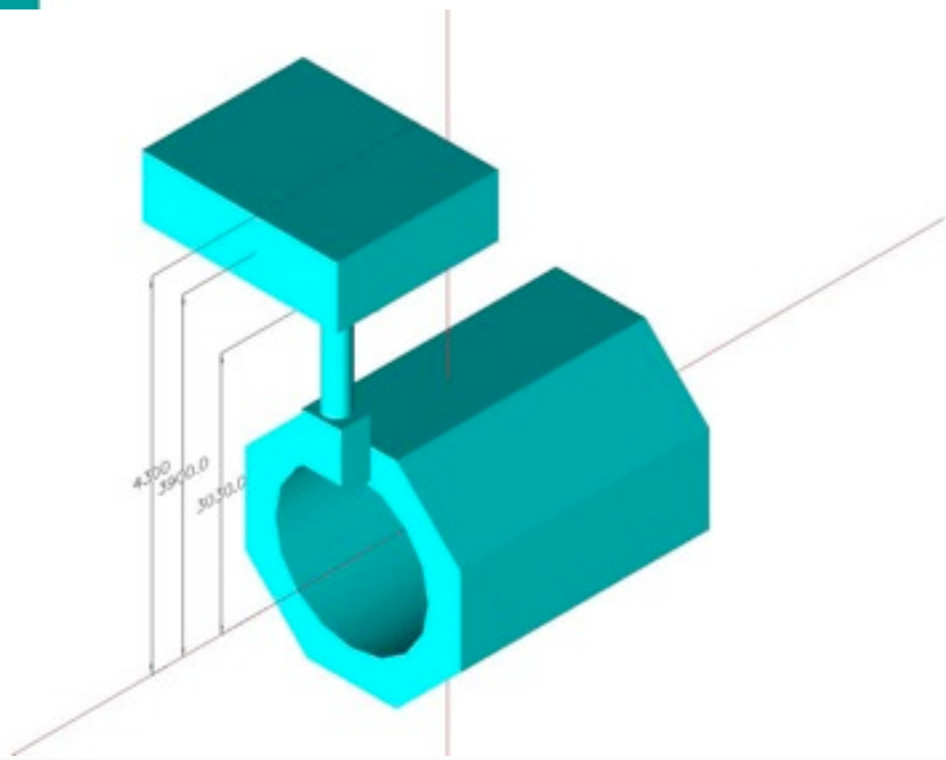
Panda Coil Keep away zone



Panda Coil Keep away zone

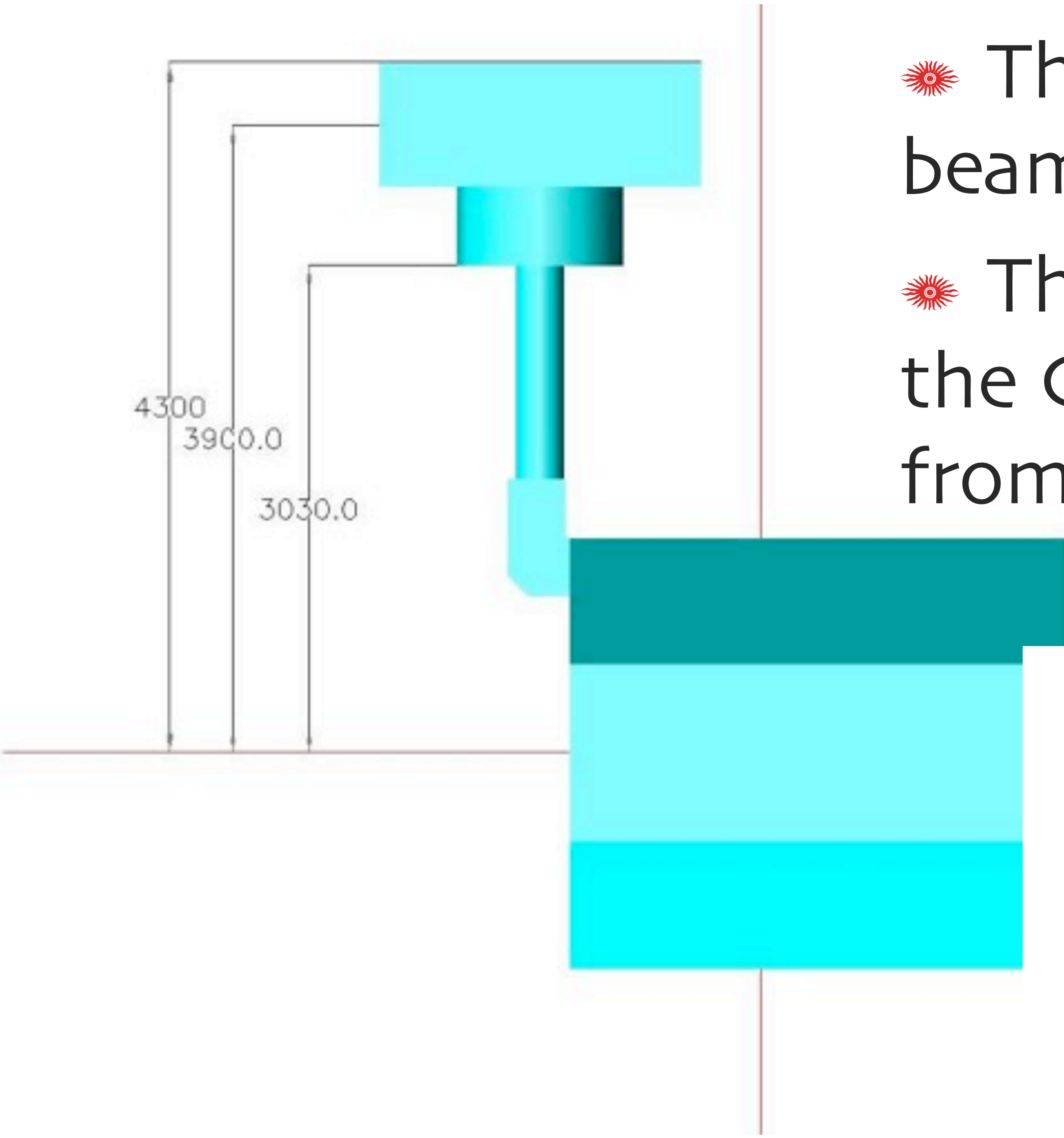


- The total height from the beam line is now 4300mm

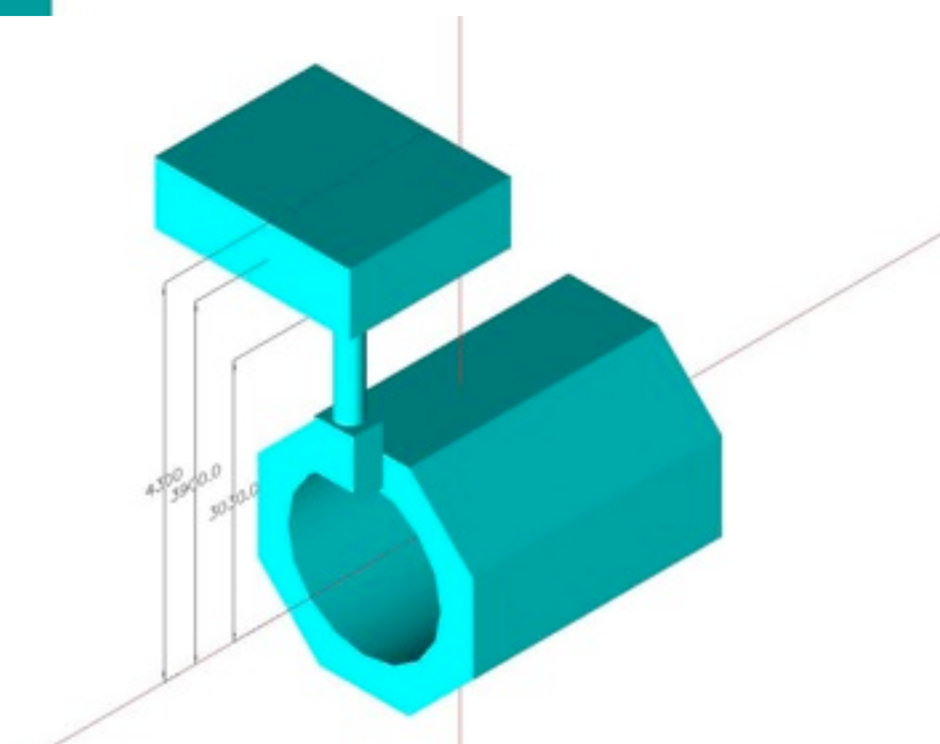


Tuesday, March 9, 2010

Panda Coil Keep away zone



- The total height from the beam line is now 4300mm
- The clear headroom below the Control dewar is 3030mm from the beam axis.



The Chimney Junction Box

The Chimney Junction Box

- A modification in the design of the lower part of the chimney has been requested by the DIRC people

The Chimney Junction Box

- A modification in the design of the lower part of the chimney has been requested by the DIRC people
- The design of the flange has been radically modified to allow more space for the DIRC readout electronics

The Chimney Junction Box

- A modification in the design of the lower part of the chimney has been requested by the DIRC people
- The design of the flange has been radically modified to allow more space for the DIRC readout electronics
- The new version fits the previous requirements

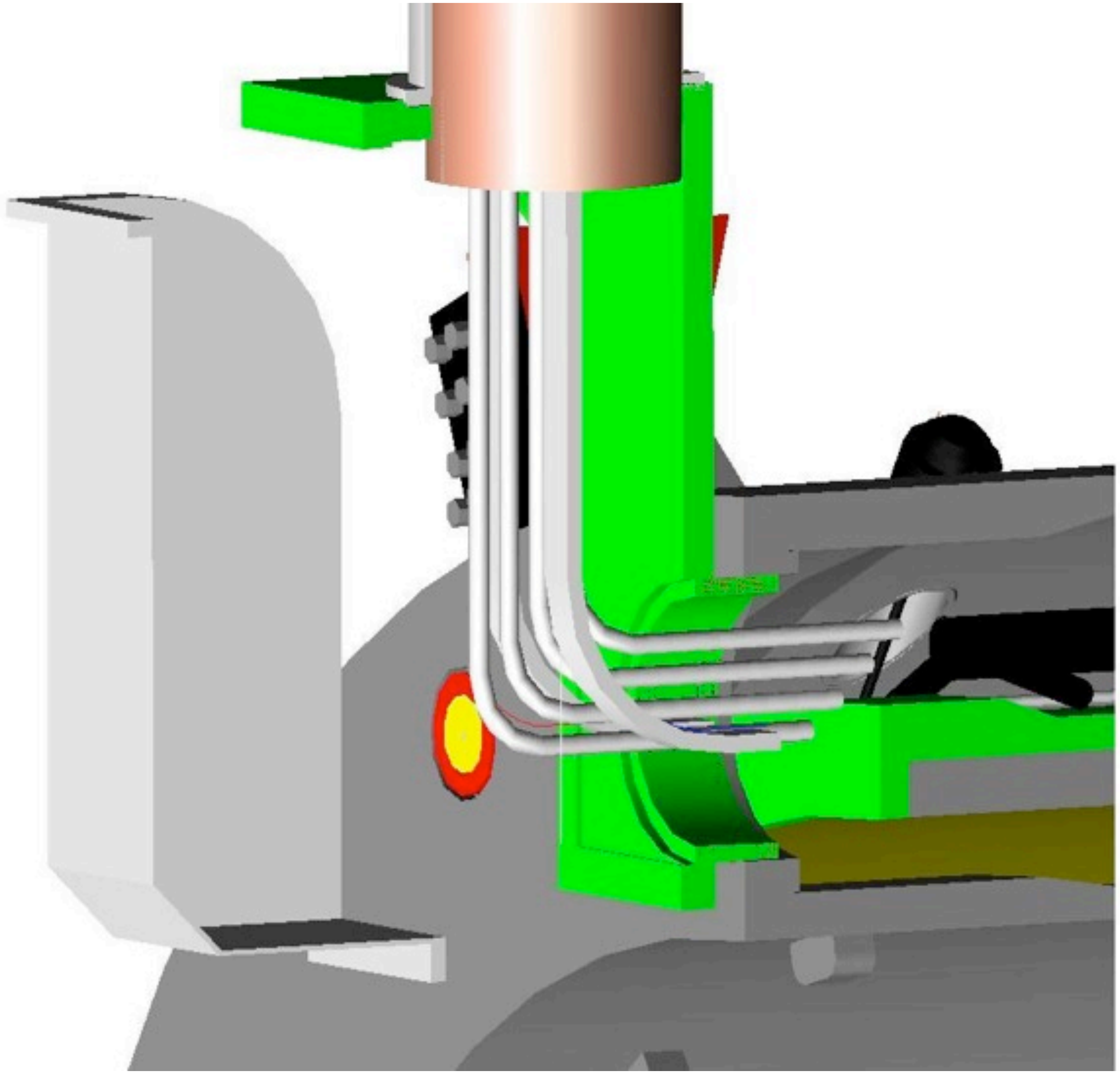
The Chimney Junction Box

- A modification in the design of the lower part of the chimney has been requested by the DIRC people
- The design of the flange has been radically modified to allow more space for the DIRC readout electronics
- The new version fits the previous requirements
- The feasibility has been checked with INFN Genova mechanical workshop

The Chimney Junction Box

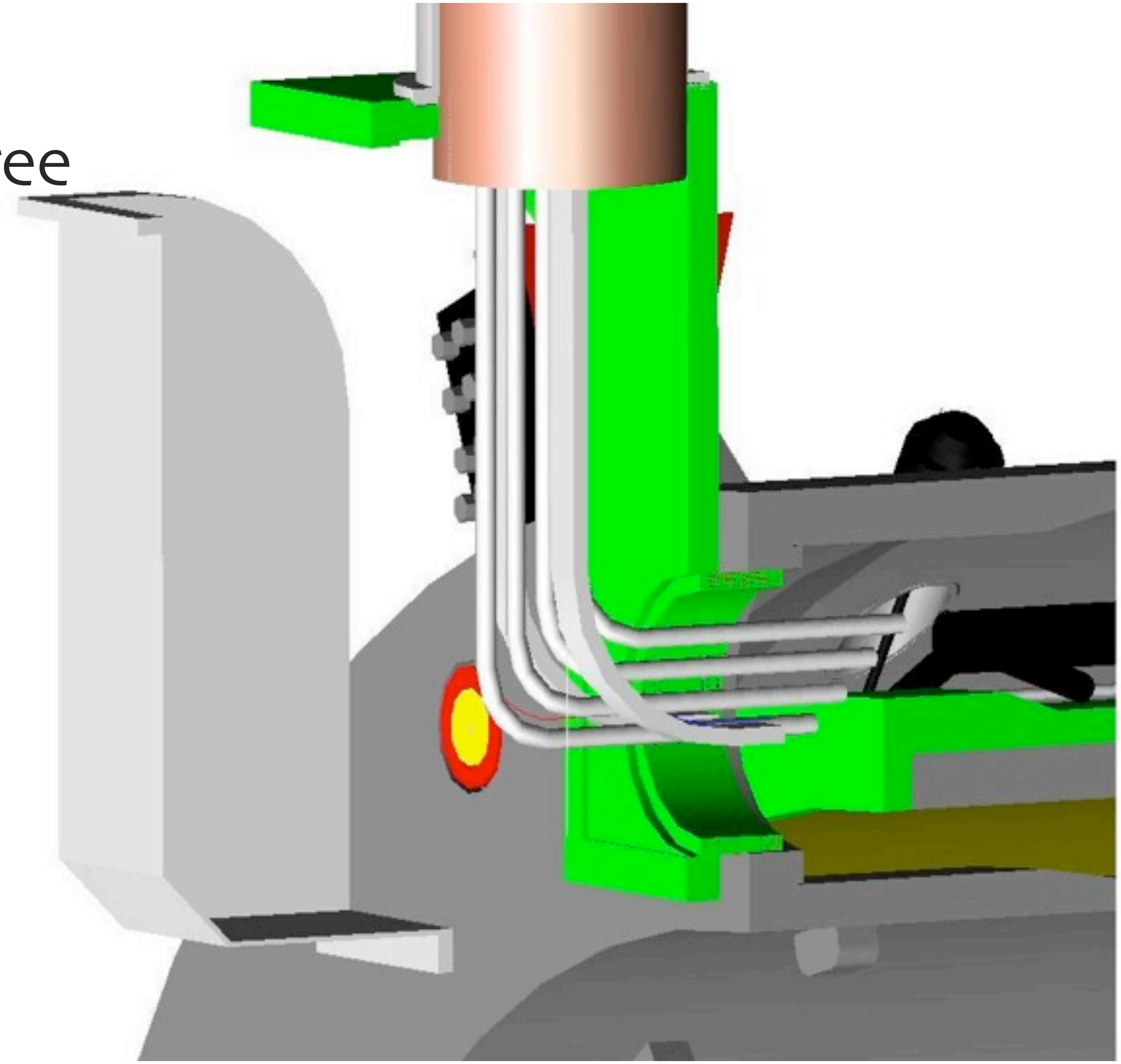
- A modification in the design of the lower part of the chimney has been requested by the DIRC people
- The design of the flange has been radically modified to allow more space for the DIRC readout electronics
- The new version fits the previous requirements
- The feasibility has been checked with INFN Genova mechanical workshop
- This change, anyhow, reflects in a possible cost and time increase

The New Junction Box



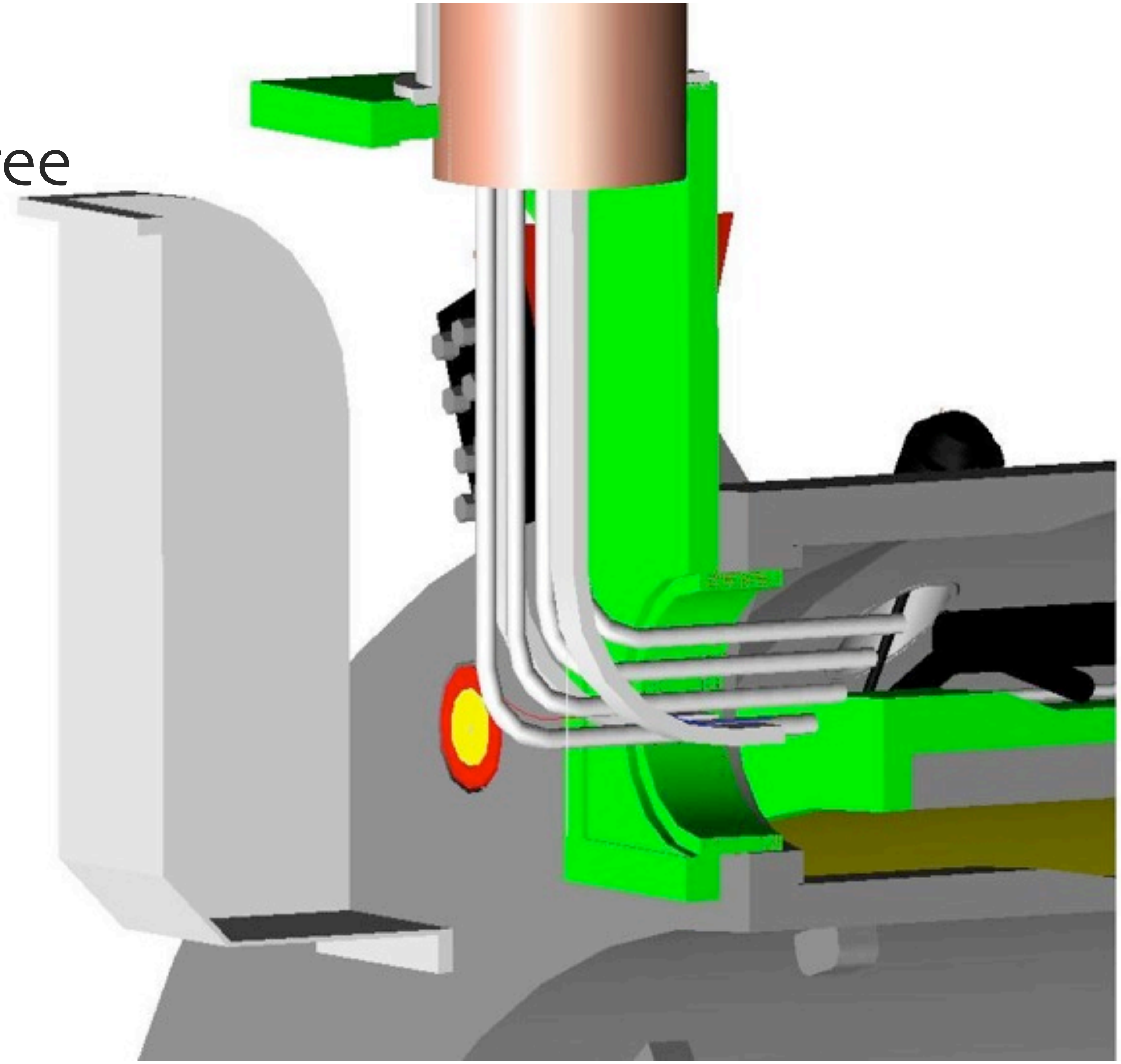
The New Junction Box

- The two busbars are obtained by three SC cables welded together



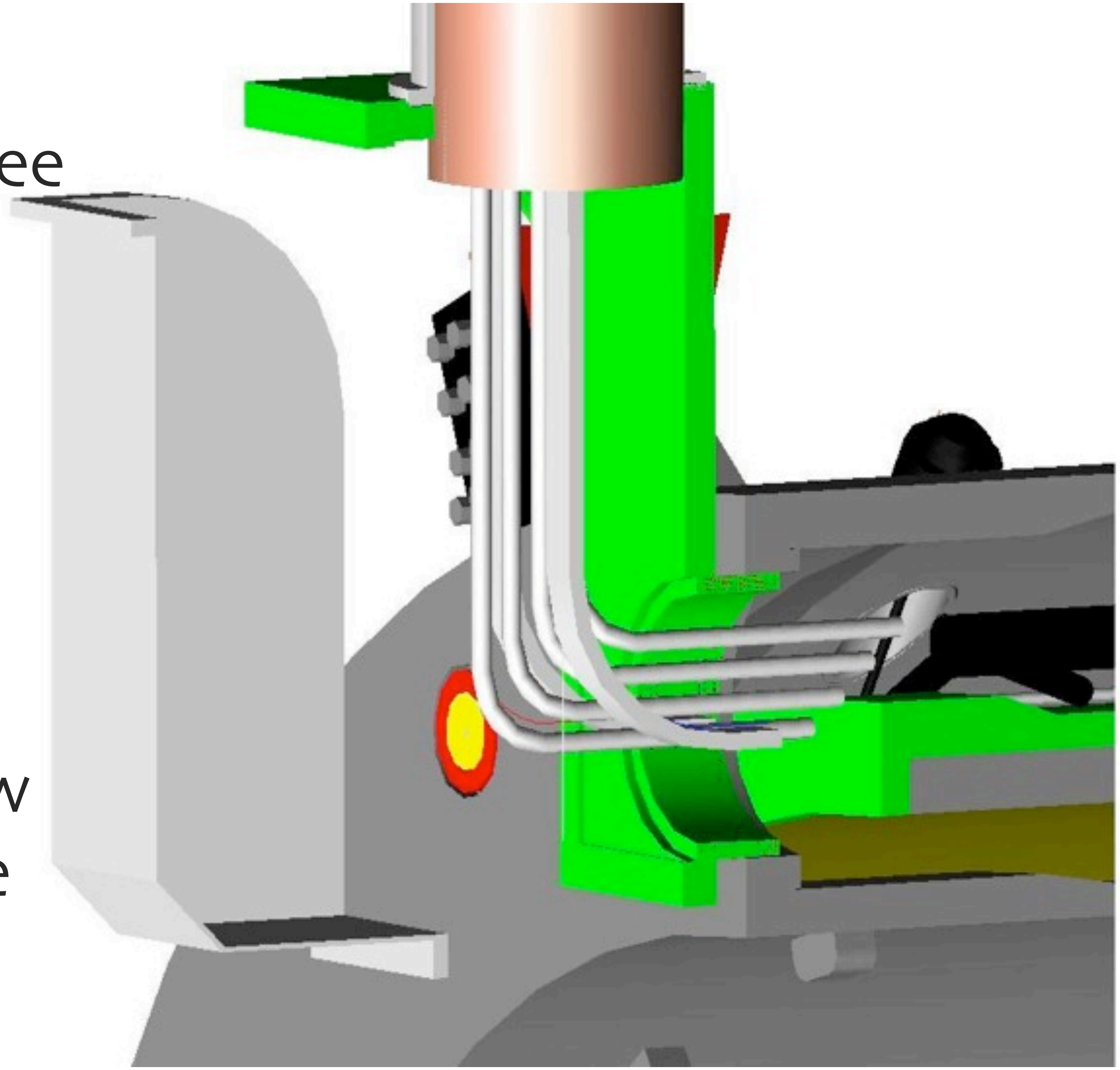
The New Junction Box

- The two busbars are obtained by three SC cables welded together
- The four pipes bring LHe and cold helium gas



The New Junction Box

- The two busbars are obtained by three SC cables welded together
- The four pipes bring LHe and cold helium gas
- The modification was needed to allow this small cut in the edge



Coil Cool-Down Procedure

Coil Cool-Down Procedure

- An estimation of the cool-down time has been done

Coil Cool-Down Procedure

- An estimation of the cool-down time has been done
- These estimations are based on “reasonable” assumptions

Coil Cool-Down Procedure

- An estimation of the cool-down time has been done
- These estimations are based on "reasonable" assumptions
- The refrigerator foreseen for the PANDA solenoid is rated for 100 l/h of LHe or 280 W @ 4.5 K

Coil Cool-Down Procedure

- An estimation of the cool-down time has been done
- These estimations are based on “reasonable” assumptions
- The refrigerator foreseen for the PANDA solenoid is rated for 100 l/h of LHe or 280 W @ 4.5 K
- We want to avoid large temperature difference in the cold mass (to avoid thermal stresses)

Coil Cool-Down Procedure

- An estimation of the cool-down time has been done
- These estimations are based on "reasonable" assumptions
- The refrigerator foreseen for the PANDA solenoid is rated for 100 l/h of LHe or 280 W @ 4.5 K
- We want to avoid large temperature difference in the cold mass (to avoid thermal stresses)
- We must cope with the cooling circuit impedance

Coil Cool-Down Procedure

- An estimation of the cool-down time has been done
- These estimations are based on "reasonable" assumptions
- The refrigerator foreseen for the PANDA solenoid is rated for 100 l/h of LHe or 280 W @ 4.5 K
- We want to avoid large temperature difference in the cold mass (to avoid thermal stresses)
- We must cope with the cooling circuit impedance
- The cold mass is ~ 4.2 t, the enthalpy variation between 300 and 4.5 K is $2.3 \cdot 10^8$ J

Minimum Cool-Down Time

Minimum Cool-Down Time

- The minimum theoretical cool-down time can be evaluated assuming to circulate all the produced LHe in the cooling circuit, 3.5 g/s at 4.5 K, and recovering it as a gas at 300 K

Minimum Cool-Down Time

- The minimum theoretical cool-down time can be evaluated assuming to circulate all the produced LHe in the cooling circuit, 3.5 g/s at 4.5 K, and recovering it as a gas at 300 K
- All the enthalpy is transferred from the cold mass to the coolant (perfect thermal exchange regime)

Minimum Cool-Down Time

- The minimum theoretical cool-down time can be evaluated assuming to circulate all the produced LHe in the cooling circuit, 3.5 g/s at 4.5 K, and recovering it as a gas at 300 K
- All the enthalpy is transferred from the cold mass to the coolant (perfect thermal exchange regime)
- With these assumptions, the cool-down time is of the order of 12 hours

Minimum Cool-Down Time

- The minimum theoretical cool-down time can be evaluated assuming to circulate all the produced LHe in the cooling circuit, 3.5 g/s at 4.5 K, and recovering it as a gas at 300 K
- All the enthalpy is transferred from the cold mass to the coolant (perfect thermal exchange regime)
- With these assumptions, the cool-down time is of the order of 12 hours
- However, this scenario is unrealistic, due to pressure and temperature gradients considerations

Realistic Cool-Down Time

Realistic Cool-Down Time

- A more realistic scenario is to cool down the coil using a mixture of liquid Helium and warm gas (300 K from in the control dewar using the CV3 cold valve to keep the temperature difference between the input and output of the coil below 50 K)

Realistic Cool-Down Time

- A more realistic scenario is to cool down the coil using a mixture of liquid Helium and warm gas (300 K from in the control dewar using the CV3 cold valve to keep the temperature difference between the input and output of the coil below 50 K)
- The second assumption is to use a constant flow of coolant of 0.5 g/sec (10Nm^3/h STP) to account for the hydraulic impedance of the cooling loops

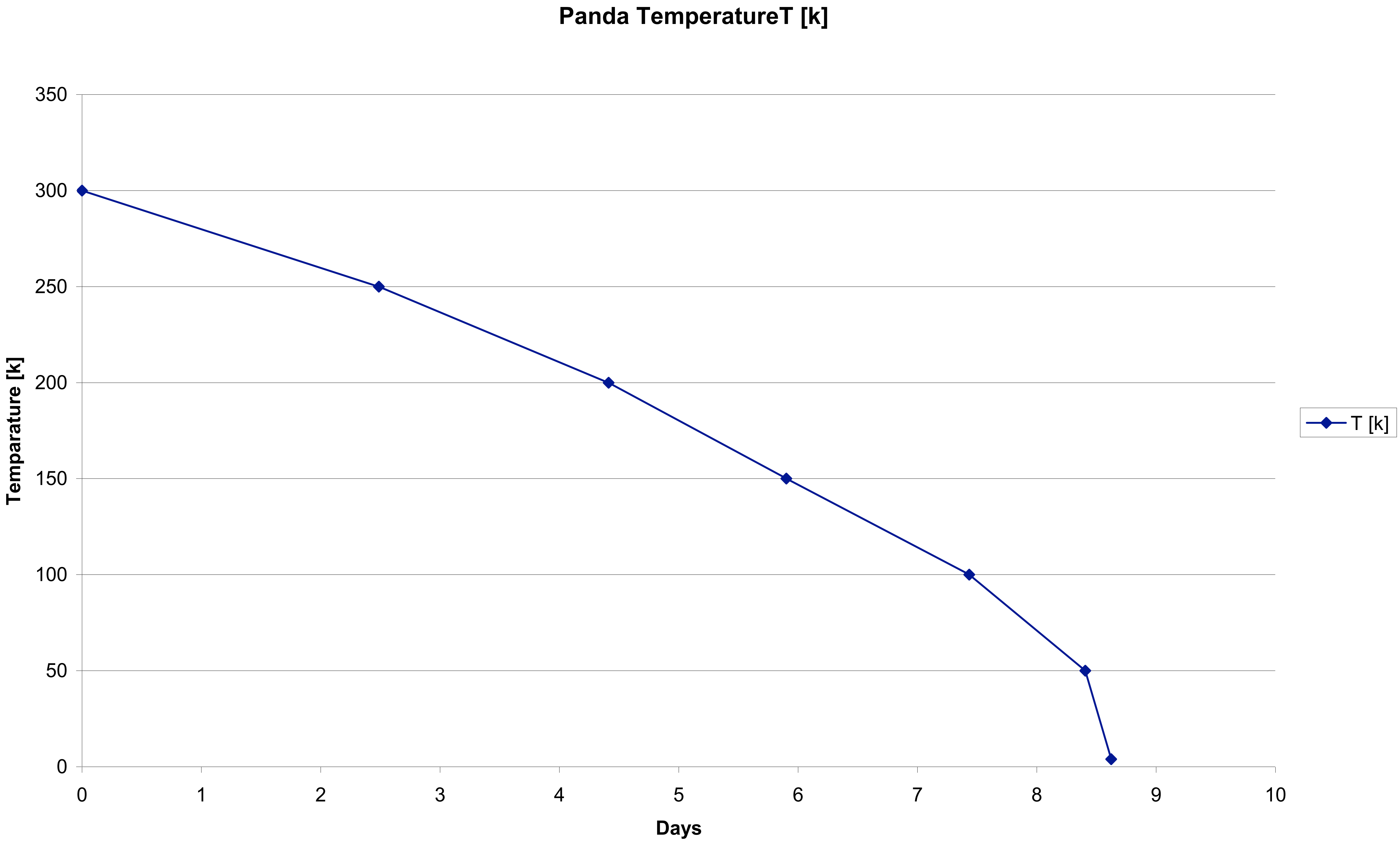
Realistic Cool-Down Time

- A more realistic scenario is to cool down the coil using a mixture of liquid Helium and warm gas (300 K from in the control dewar using the CV3 cold valve to keep the temperature difference between the input and output of the coil below 50 K)
- The second assumption is to use a constant flow of coolant of 0.5 g/sec (10Nm^3/h STP) to account for the hydraulic impedance of the cooling loops
- The second assumption is a quite conservative guess

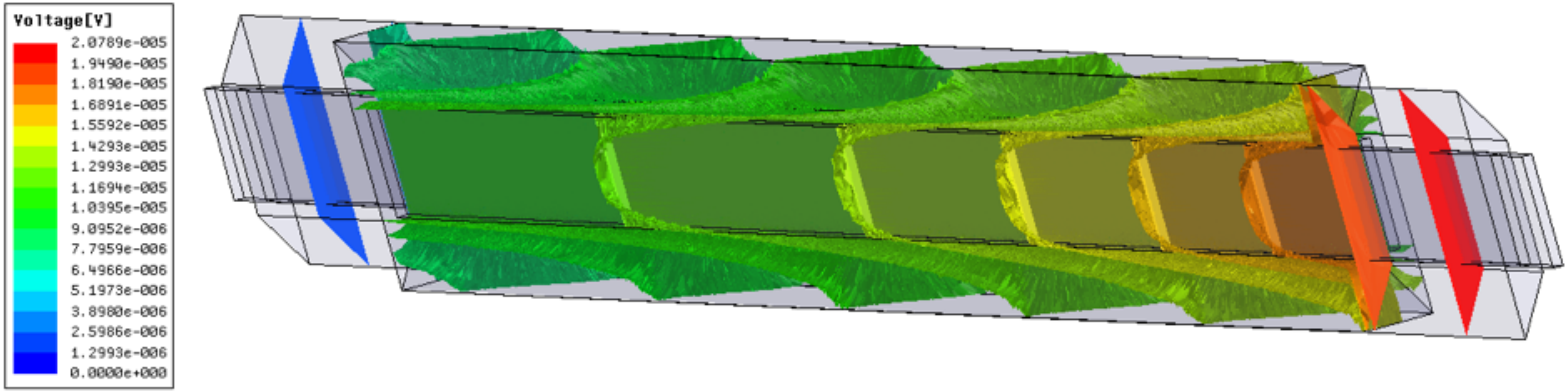
Realistic Cool-Down Time

- A more realistic scenario is to cool down the coil using a mixture of liquid Helium and warm gas (300 K from in the control dewar using the CV3 cold valve to keep the temperature difference between the input and output of the coil below 50 K)
- The second assumption is to use a constant flow of coolant of 0.5 g/sec (10Nm^3/h STP) to account for the hydraulic impedance of the cooling loops
- The second assumption is a quite conservative guess
- The realistic cool-down time is ~8 days

Temperature Profile

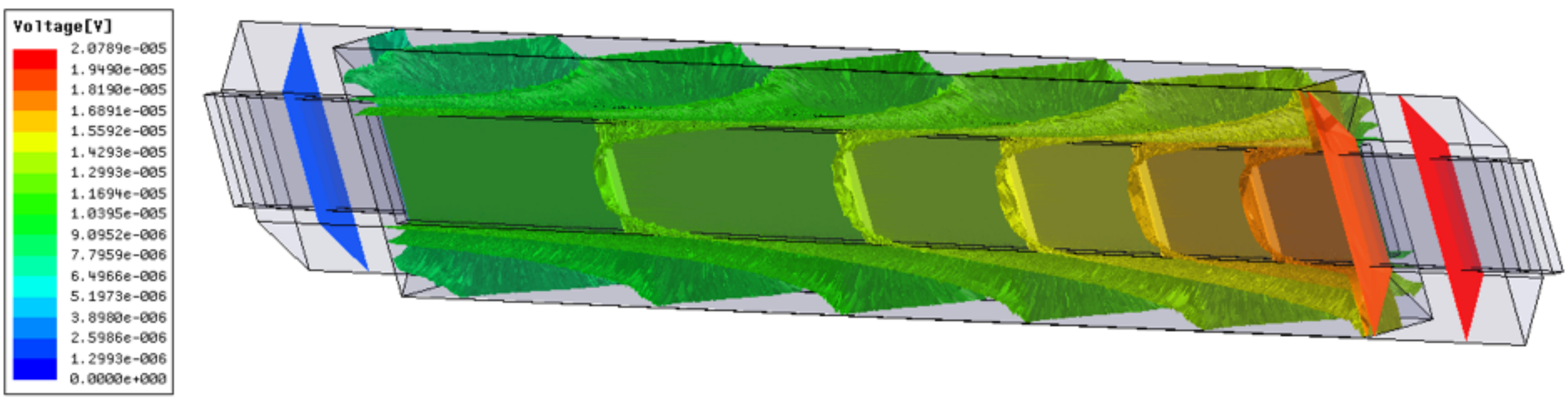


Joint Losses



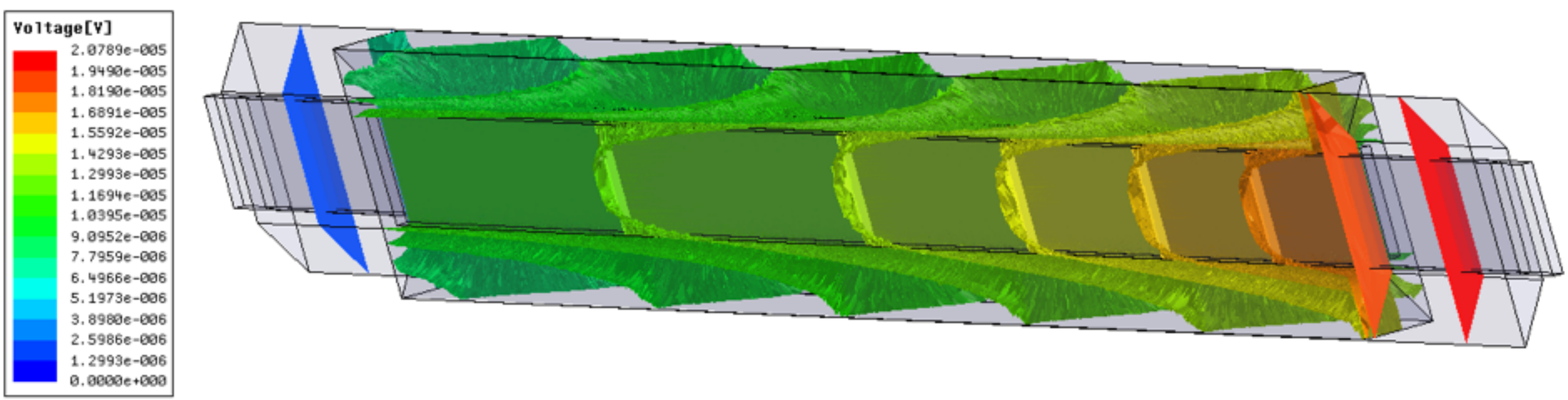
Joint Losses

- The resistance of the cable joints has been evaluated in a 3D finite element model



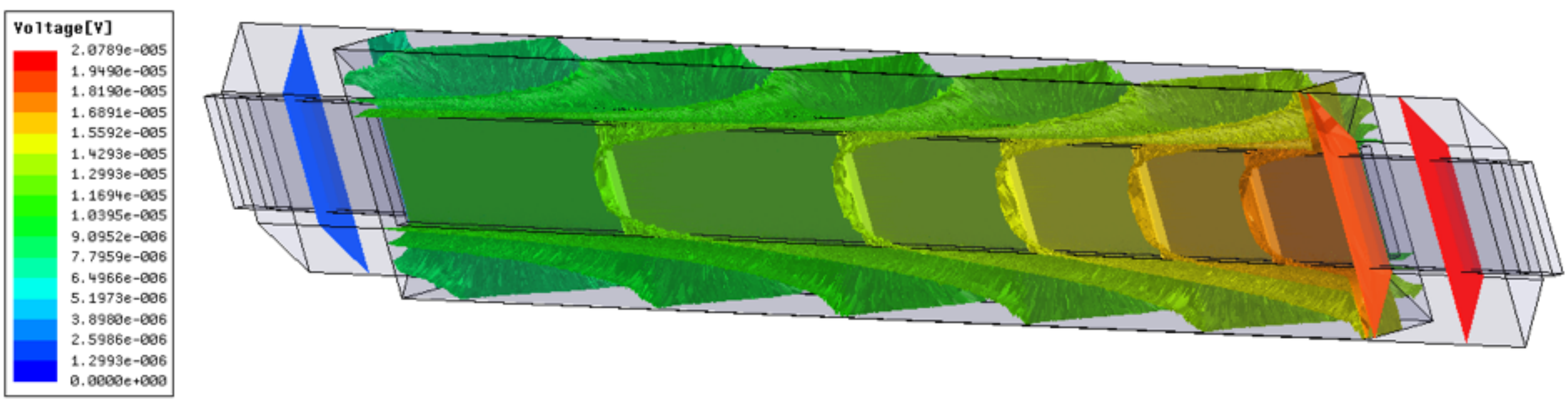
Joint Losses

- The resistance of the cable joints has been evaluated in a 3D finite element model
- It is foreseen to weld the two ends of cable pieces welding the aluminium matrix with the TIG technique

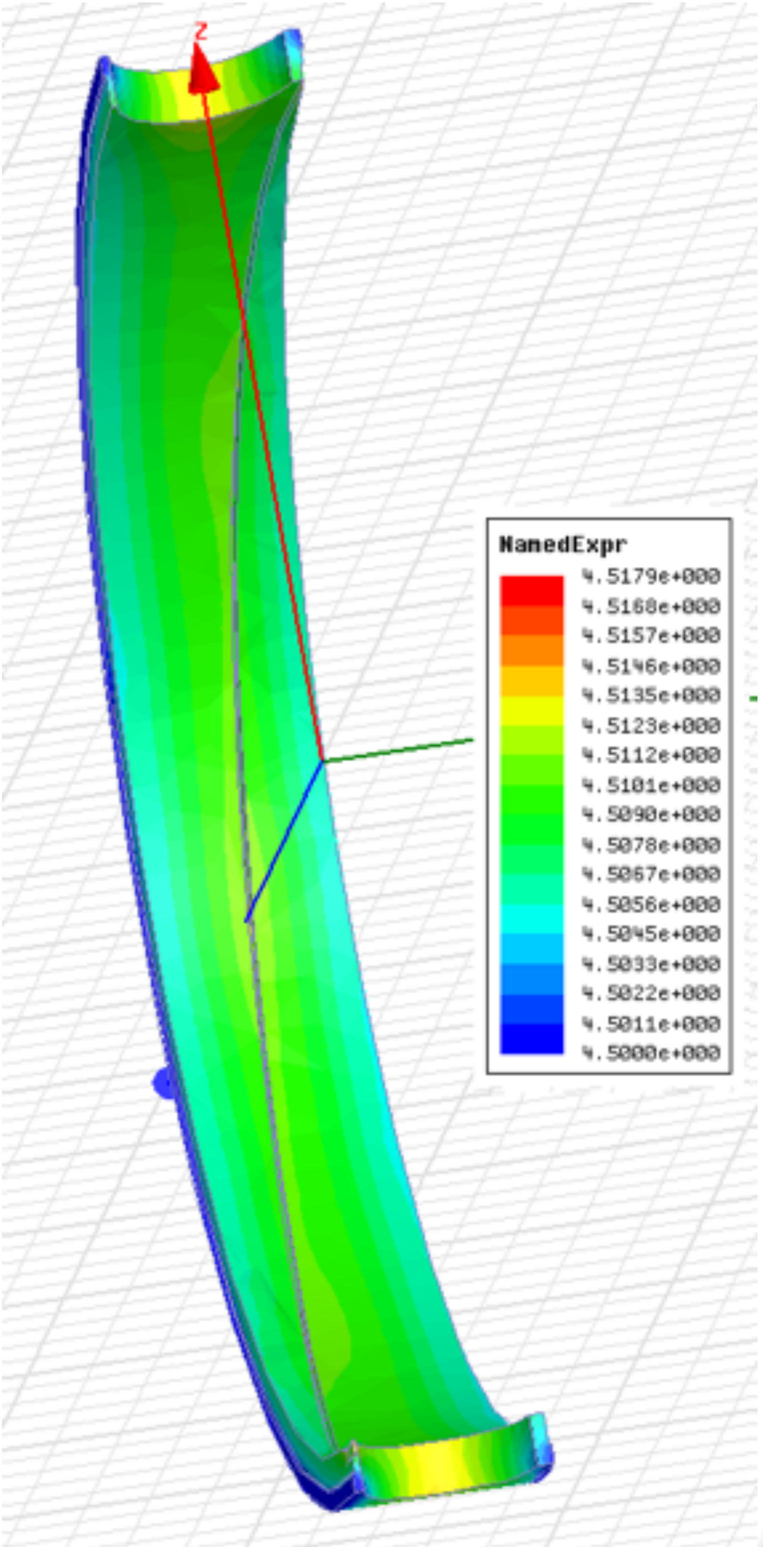


Joint Losses

- The resistance of the cable joints has been evaluated in a 3D finite element model
- It is foreseen to weld the two ends of cable pieces welding the aluminium matrix with the TIG technique
- From the voltage drop map the resistance has been calculated to be ~ $5 \cdot 10^{-11}\ \Omega$

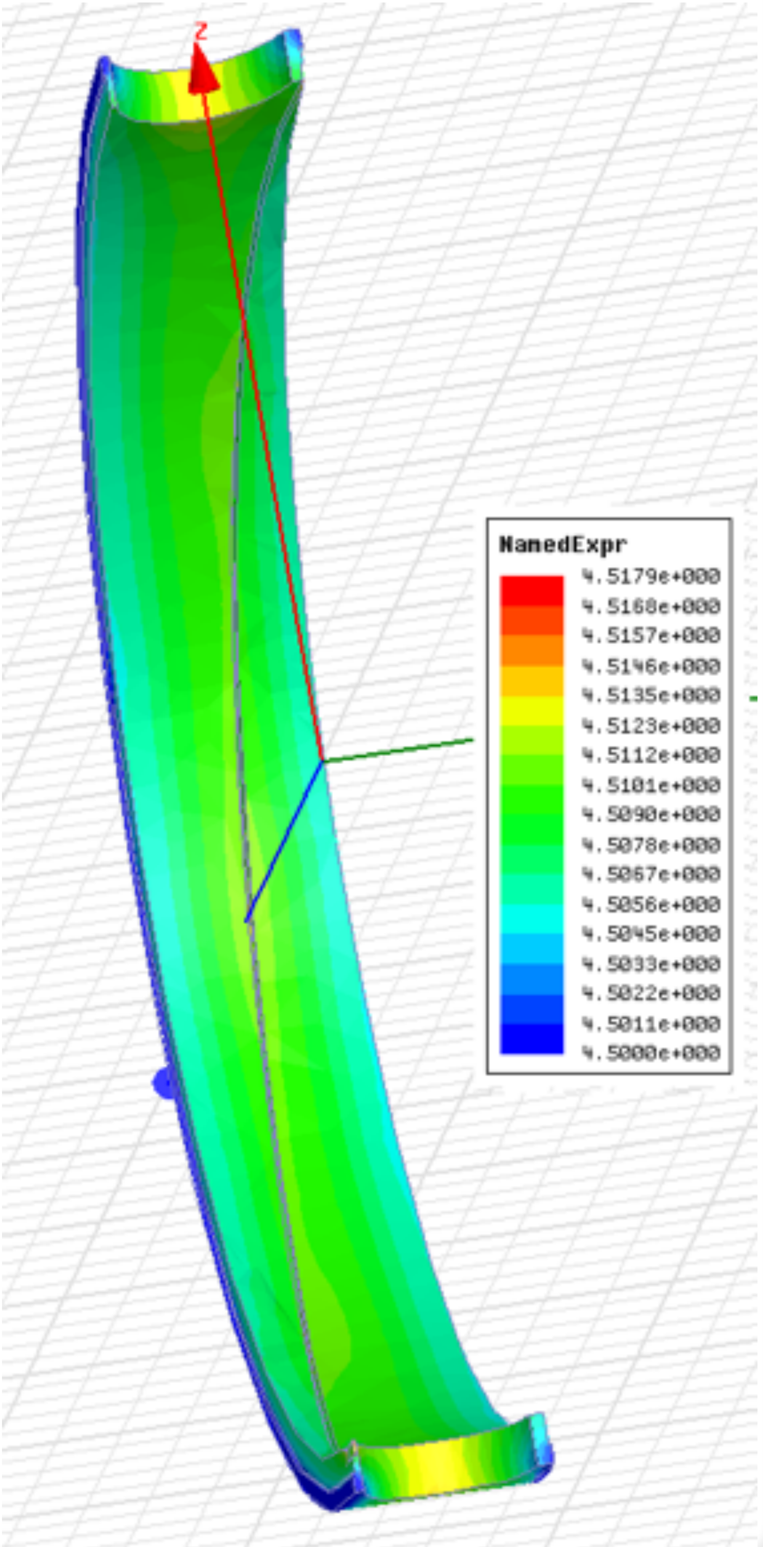


Heating from the Cable Joints



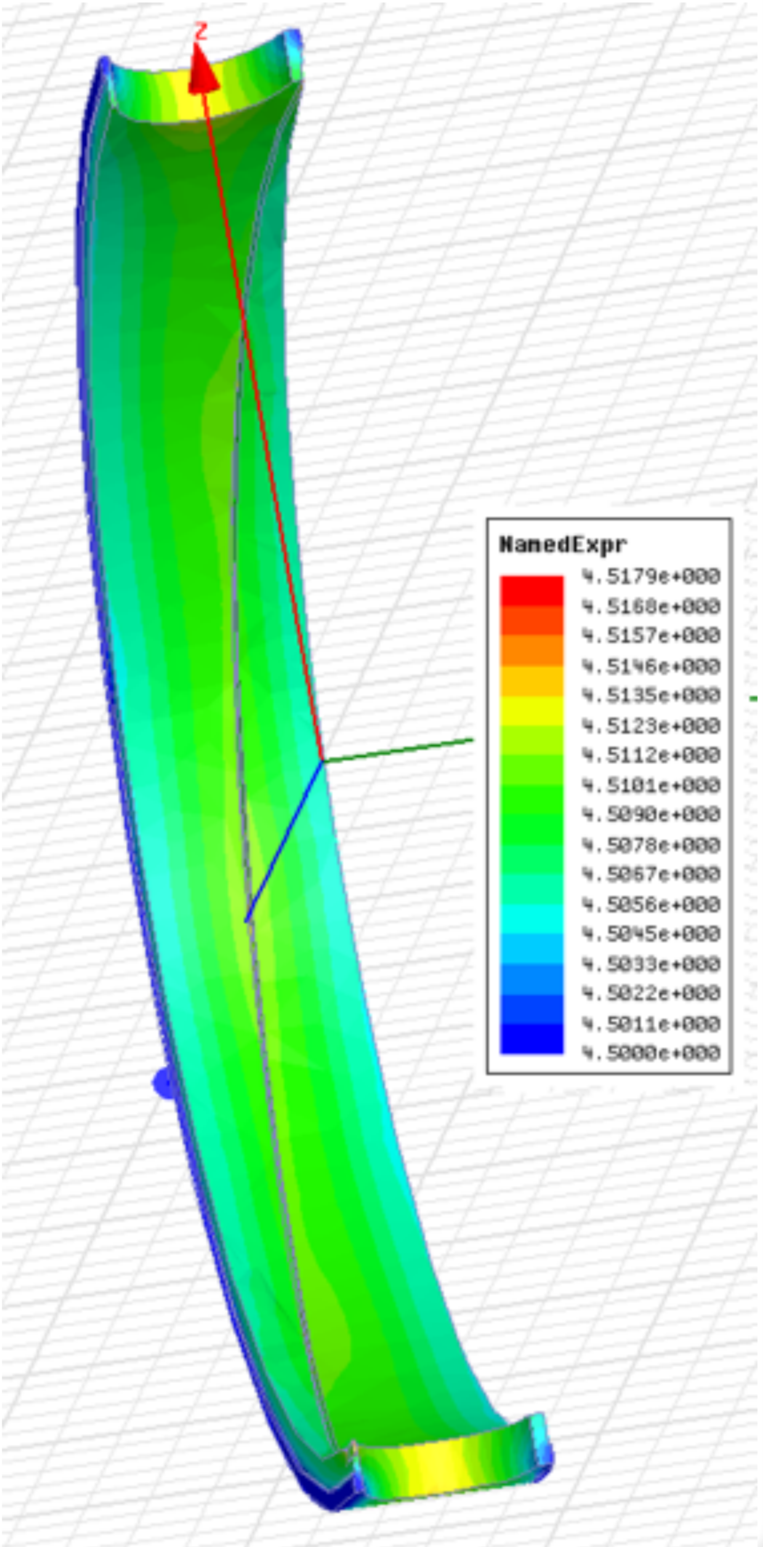
Heating from the Cable Joints

- The heat input per joint has been evaluated to be approximately 1.25 mW



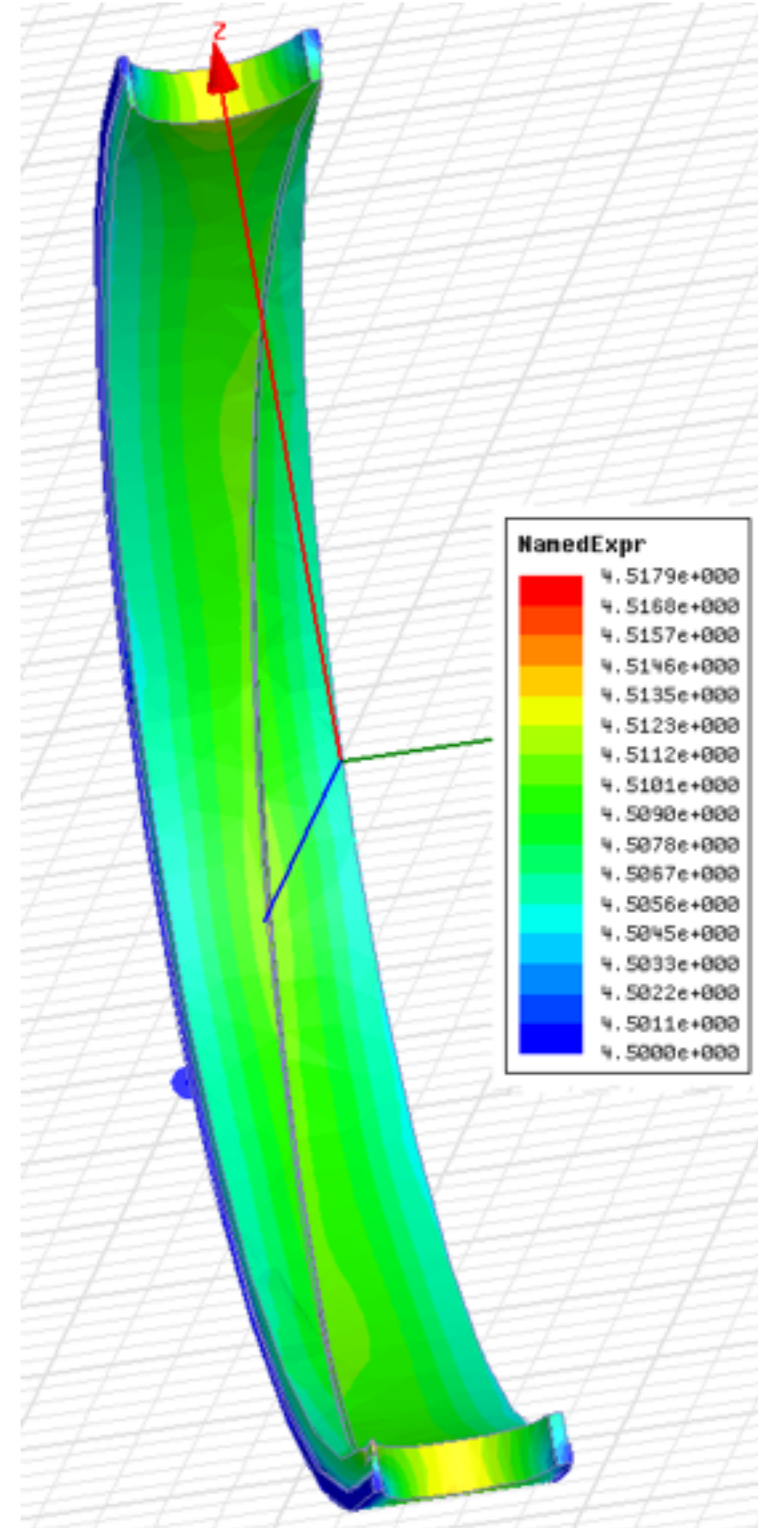
Heating from the Cable Joints

- The heat input per joint has been evaluated to be approximately 1.25 mW
- This is negligible w.r.t. the radiation heat load in a section between two cooling pipes, evaluated in 150 mW



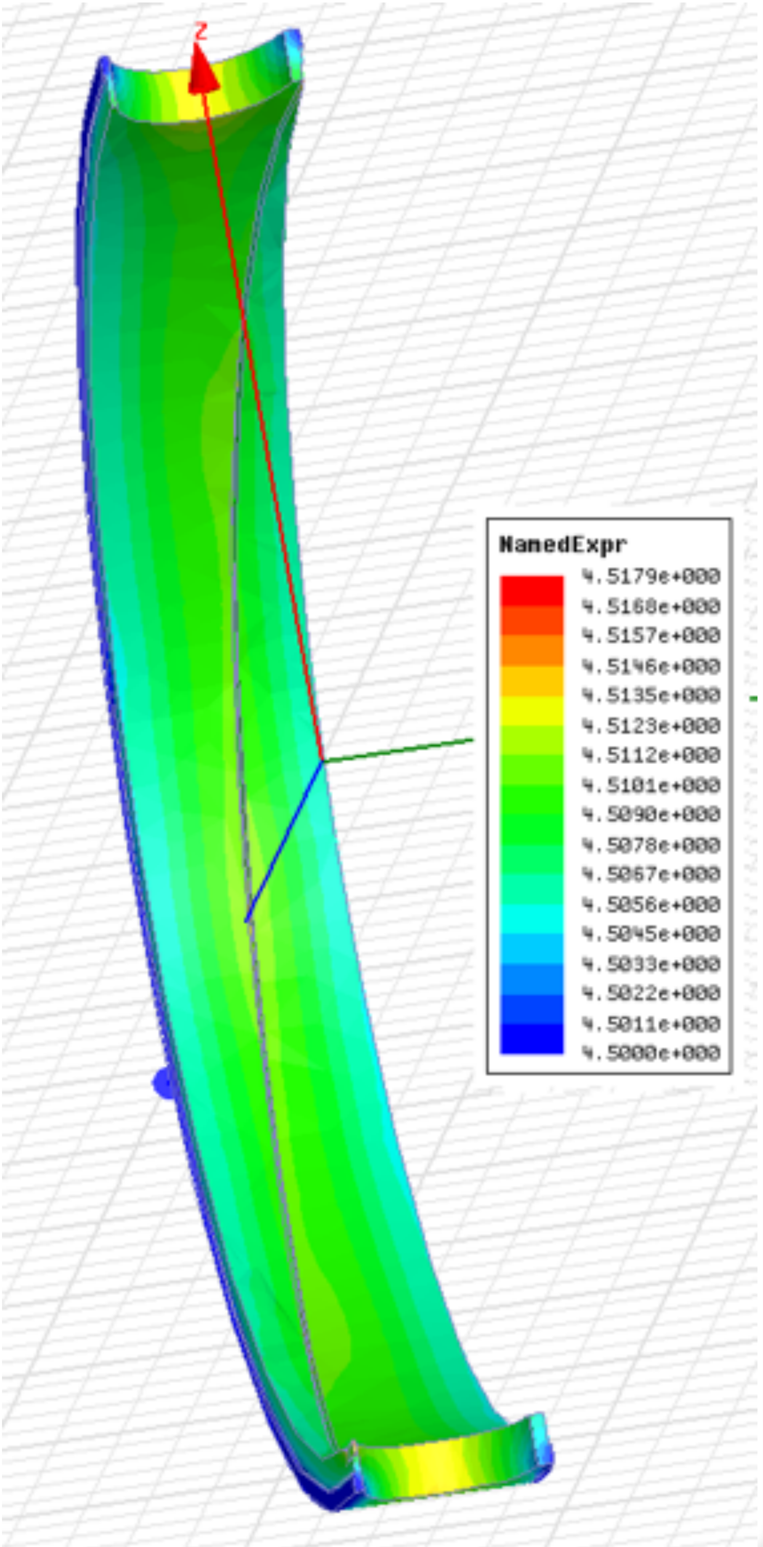
Heating from the Cable Joints

- The heat input per joint has been evaluated to be approximately 1.25 mW
- This is negligible w.r.t. the radiation heat load in a section between two cooling pipes, evaluated in 150 mW
- It is negligible w.r.t. the conduction heat load due to the axial supports, evaluated to be 140 mW



Heating from the Cable Joints

- The heat input per joint has been evaluated to be approximately 1.25 mW
- This is negligible w.r.t. the radiation heat load in a section between two cooling pipes, evaluated in 150 mW
- It is negligible w.r.t. the conduction heat load due to the axial supports, evaluated to be 140 mW
- The effect on the temperature map of the joint is not appreciable in the FE calculation



New Thermal Simulation

New Thermal Simulation

- Following the increasing detail in the cold mass design, a new set of FE thermal calculations have been performed

New Thermal Simulation

- Following the increasing detail in the cold mass design, a new set of FE thermal calculations have been performed
- Comsol MultiPhysics code has been used in addition to ePhysics to make a comparison possible

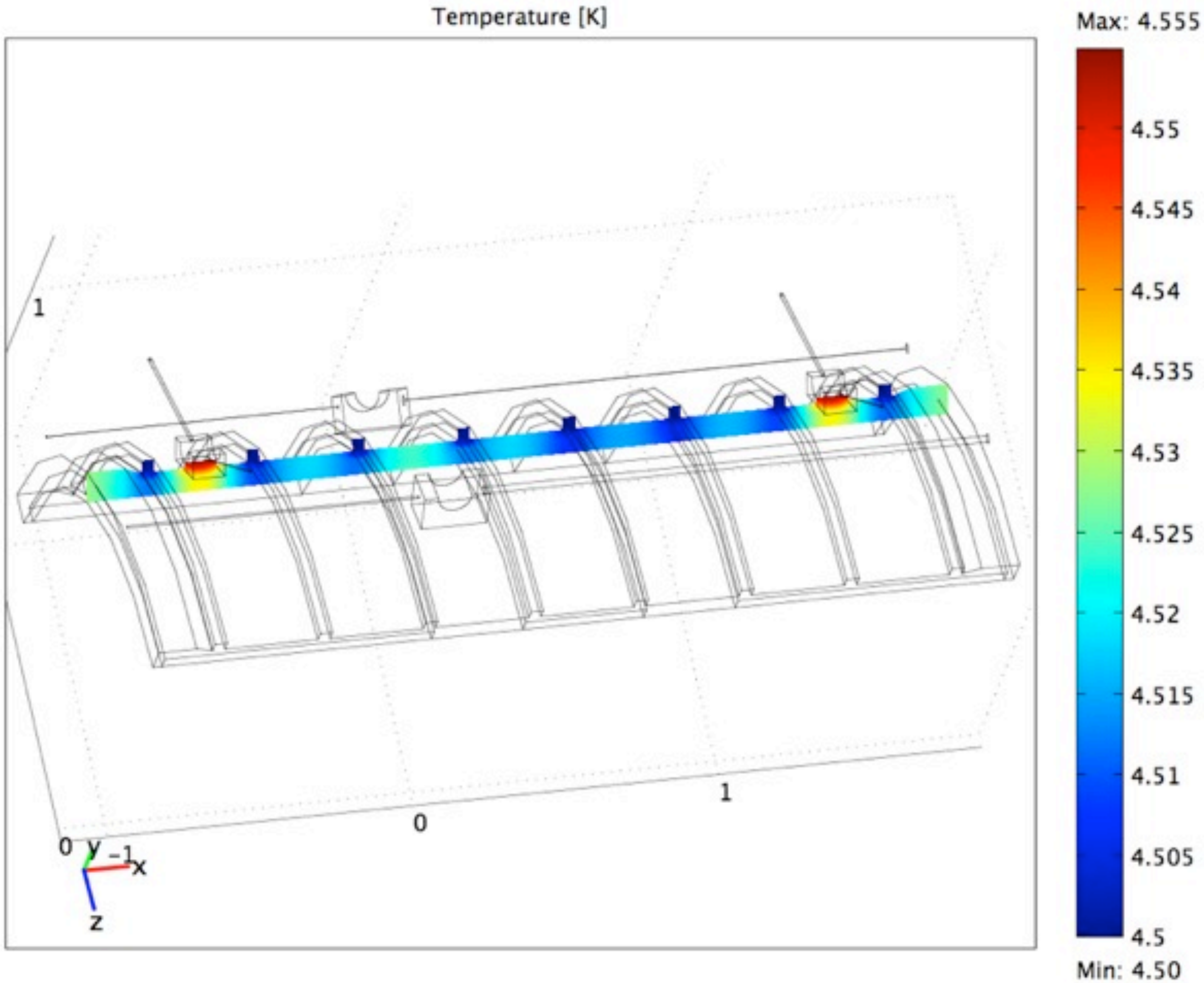
New Thermal Simulation

- Following the increasing detail in the cold mass design, a new set of FE thermal calculations have been performed
- Comsol MultiPhysics code has been used in addition to ePhysics to make a comparison possible
- All the results are in fair agreement with the numbers quoted in the TDR

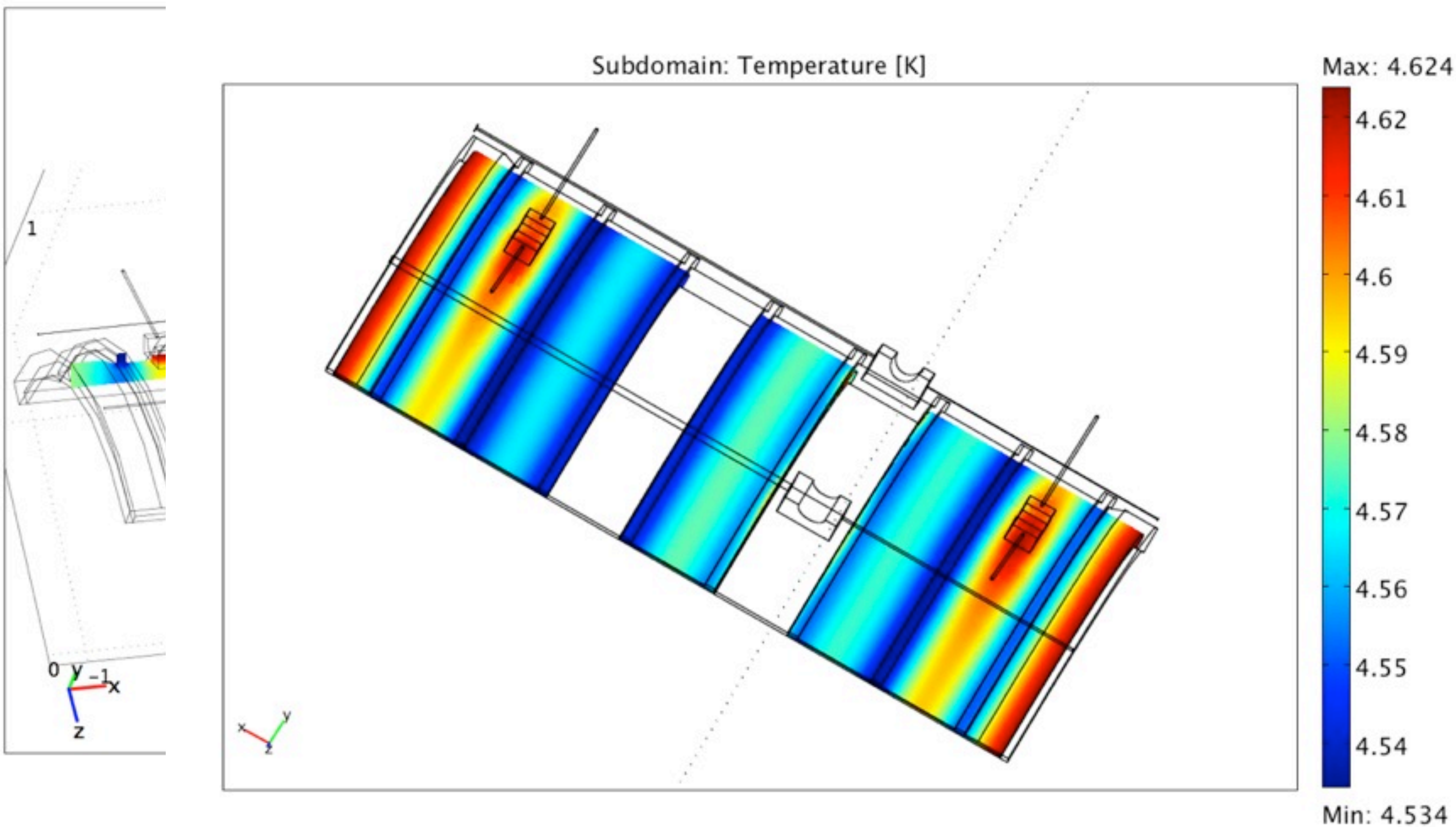
New Thermal Simulation

- Following the increasing detail in the cold mass design, a new set of FE thermal calculations have been performed
- Comsol MultiPhysics code has been used in addition to ePhysics to make a comparison possible
- All the results are in fair agreement with the numbers quoted in the TDR
- The temperature margin is confirmed

New Temperature Maps



New Temperature Maps



Conclusions

Conclusions

- No conflicts in the current design
  - DIRC compatibility
  - Doors operation

Conclusions

- No conflicts in the current design
  - DIRC compatibility
  - Doors operation
- Cool-down scenarios have been investigated

Conclusions

- No conflicts in the current design
  - DIRC compatibility
  - Doors operation
- Cool-down scenarios have been investigated
- Cable joints losses have been calculated

Conclusions

- No conflicts in the current design
  - DIRC compatibility
  - Doors operation
- Cool-down scenarios have been investigated
- Cable joints losses have been calculated
- New thermal simulations have been performed

Conclusions

- No conflicts in the current design
  - DIRC compatibility
  - Doors operation
- Cool-down scenarios have been investigated
- Cable joints losses have been calculated
- New thermal simulations have been performed
- A very preliminary, but quite complete, technical specification for the coil and cryostat tender has been added to the “Interface Document”

Open Questions

Open Questions

- Space in the PANDA Hall
  - Height of the ceiling on top of the spectrometers
  - Cryogenic lines and LHe storage location
  - Coil Power supply and quench dump location

Open Questions

- Space in the PANDA Hall
  - Height of the ceiling on top of the spectrometers
  - Cryogenic lines and LHe storage location
  - Coil Power supply and quench dump location

- Operations of the coil <u>only</u> in "in beam" position or <u>both</u> in "in beam" and in "garage" position
  - Essential to design the supply lines

Open Questions

- Space in the PANDA Hall
  - Height of the ceiling on top of the spectrometers
  - Cryogenic lines and LHe storage location
  - Coil Power supply and quench dump location

- Operations of the coil only in "in beam" position or both in "in beam" and in "garage" position
  - Essential to design the supply lines

- Last but not least, have we a satisfactory design for the cryostat suspension in the flux return yoke?