BDF Proximity shielding status update

Truls Kolstad & Mike Parkin

10/02/2025

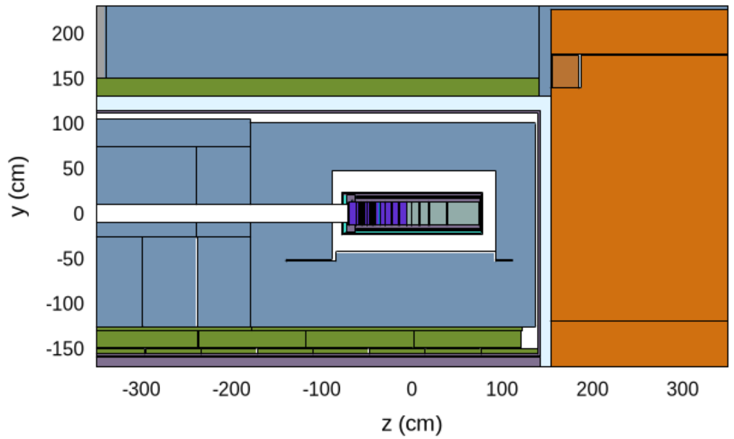
Content:

- **Shielding comparison**
  - Model used in FLUKA simulations vs Current ST model.
- **Simulation results**
  - Assumptions
  - Results
  - Notes
- **Future simulations**
  - Adaptions
- **Discussion**

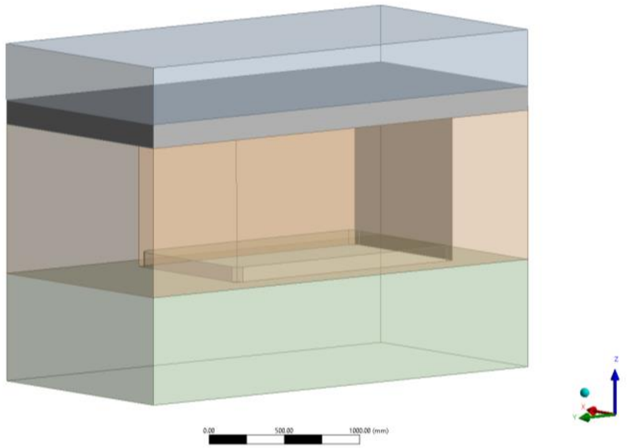
Nomenclature of models

- **FLUKA model**
  - Used within FLUKA to get energy deposition.
- **Thermo model**
  - Geometry conforming to FLUKA model. Used in current thermal simulations.
- **New ST Model**
  - Updated geometry from target complex assembly. Currently no simulation data.

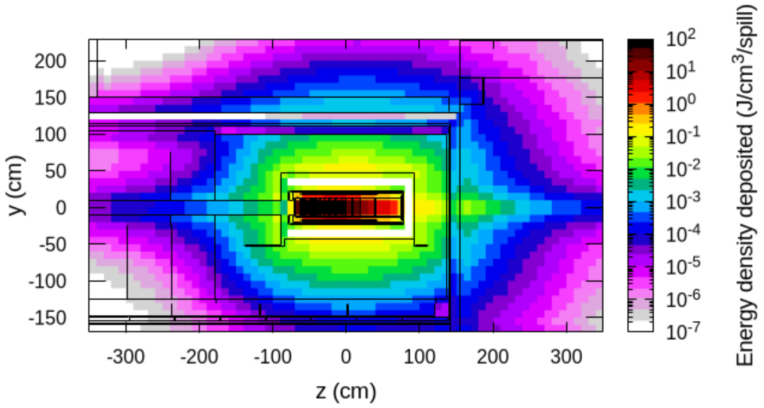
Fluka model



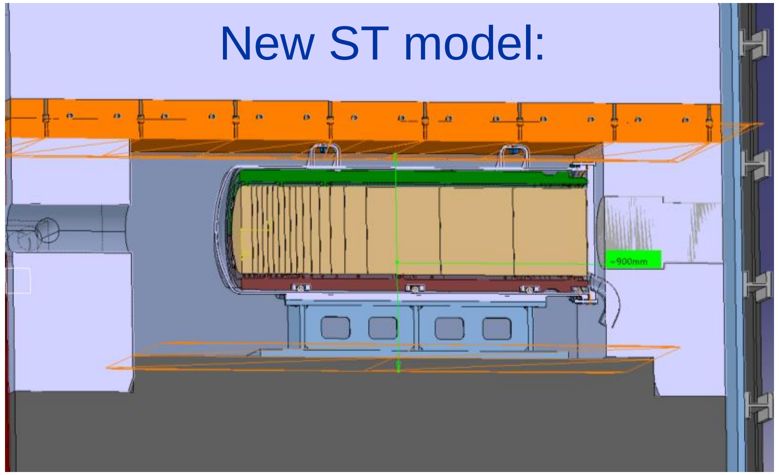
Thermo model:



Fluka model

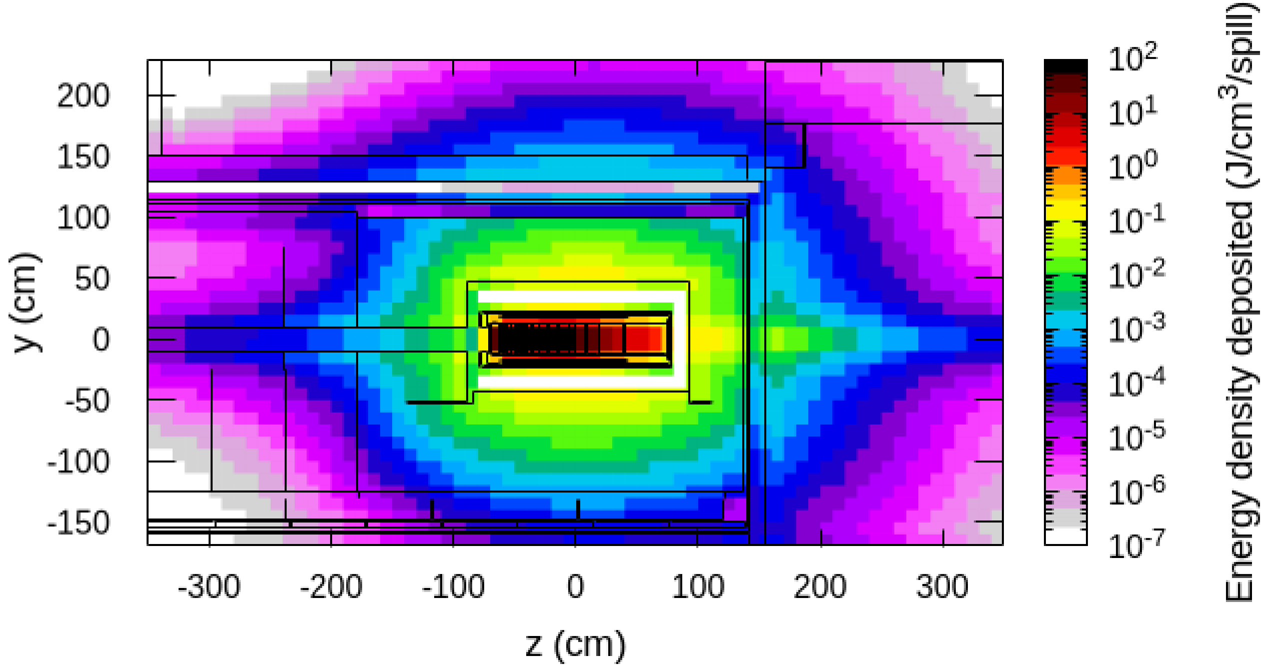


New ST model:



FLUKA simulation details

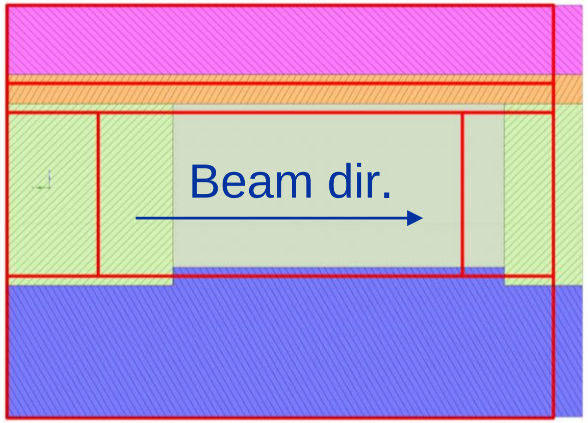
- FLUKA simulation includes entire target complex.
- In FLUKA all parts of the proximity shielding is cast iron.
- Current Thermo model corresponds to dimensions of the FLUKA model.
- FLUKA simulation outputs coordinates for the heat deposition to be used in ANSYS thermal simulations.
- Different proximity shielding dimensions would require a new FLUKA simulation to attain accurate values of energy deposition.



Shielding comparison between FLUKA model and ST file model

Parameter	FLUKA model	New ST model
Front shielding	910 mm	500 mm
Rear shielding	430 mm	500 mm
Sidewall thickness	265 mm	265 mm
Upper shielding	380 mm	428 mm
Lower shielding	820 mm	779 mm
Cooling plate thickness	160 mm	160 mm
Inner area width	1050 mm	1050 mm
Inner area length	1820 mm	2000 mm
Inner area height	900 mm	900 mm
Overall width	1580 mm	1580 mm
Overall length	3160 mm	3000 mm
Overall height	2260 mm	2267 mm

Red outline = New ST Model



Colored solids: FLUKA model

Model	FLUKA/ Thermo	New ST Model	Unit
Volume	9.564	8.856	[m^3]
Change	0%	-7.41%	[%]
Estimated energy deposition *	2353	2178	[W/m3]
Total energy deposited	22500	19291	[W]

*Assuming energy deposition scales linearly with volume, and uniform deposition in all directions. Future simulations should show more realistic effects.

Real thermal contact conductance

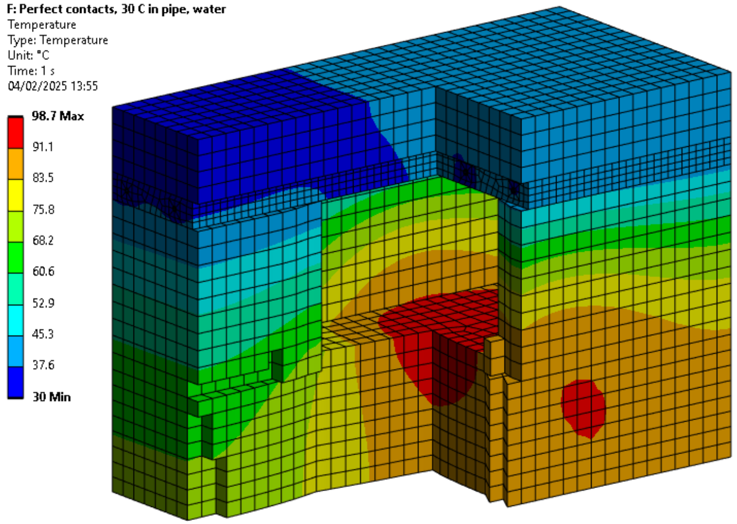
- **Using CMY*-model to approximate realistic thermal contact conductance.**
- **Dependent on:**
    - Contact pressure
    - Thermal conductance
    - Surface roughness
    - Youngs modulus
    - Asperity surface slope (approximated)

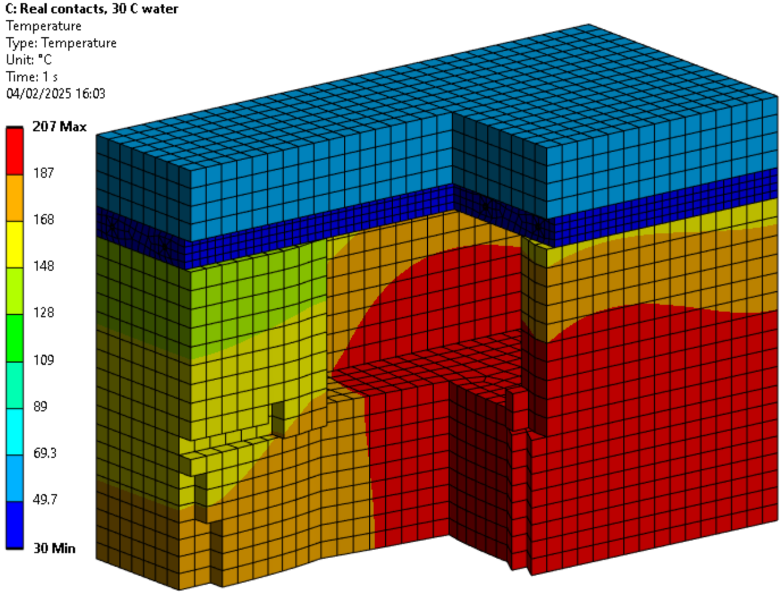
*Cooper-Mikic-Yovanovich

Simulations with FLUKA model: Water cooled top plate

- **Assuming:**
  - 30 C inside all pipes to represent ideal conditions with water cooling
  - Water cooling plate on top is cast iron with stainless-steel pipes inside the cast. Perfect thermal conductivity.
  - Assumed real conductance calculated from CMY model.

- **Conclusion:**
  - Realistic thermal contact conductance is very low and affects the cooling performance severely.
  - Cooling performance can be increased with more contact pressure and/or a copper cooling plate

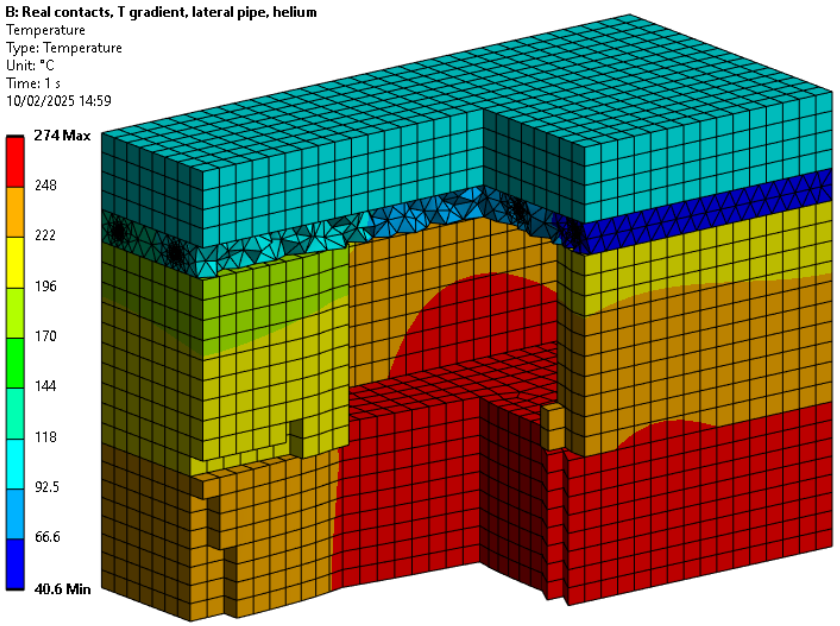


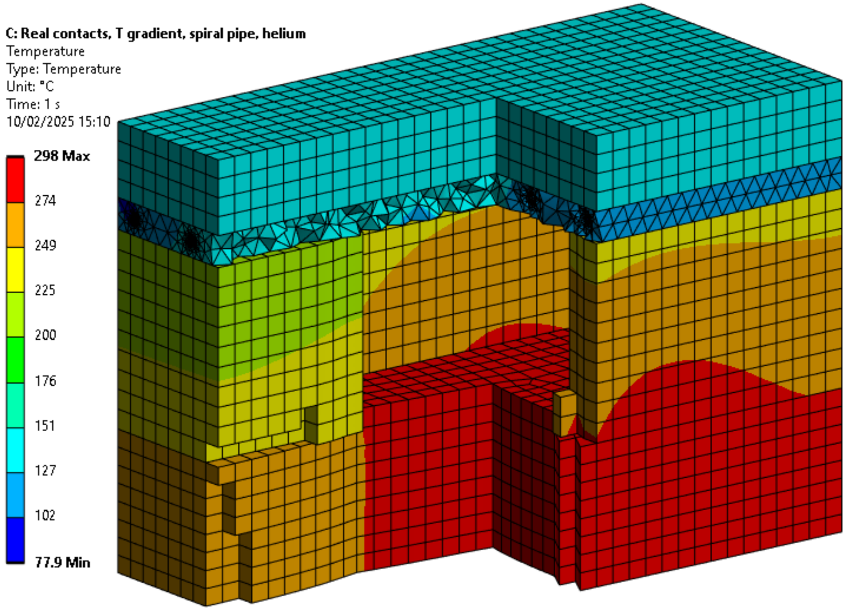


Simulations with FLUKA model: Helium cooled top plate

- **Assuming:**
  - Helium flow in cooling pipes is fully turbulent. At the inlet: 16 bar, 30 g/s, 20 C
  - Cooling plate on top is cast iron with stainless-steel pipes inside the cast. Perfect thermal conductivity.
  - Assumed real conductance calculated from CMY model.

- **Conclusion:**
  - Realistic thermal contact conductance is very low and affects the cooling performance severely.
  - Cooling performance can be increased with more contact pressure and/or a copper cooling plate

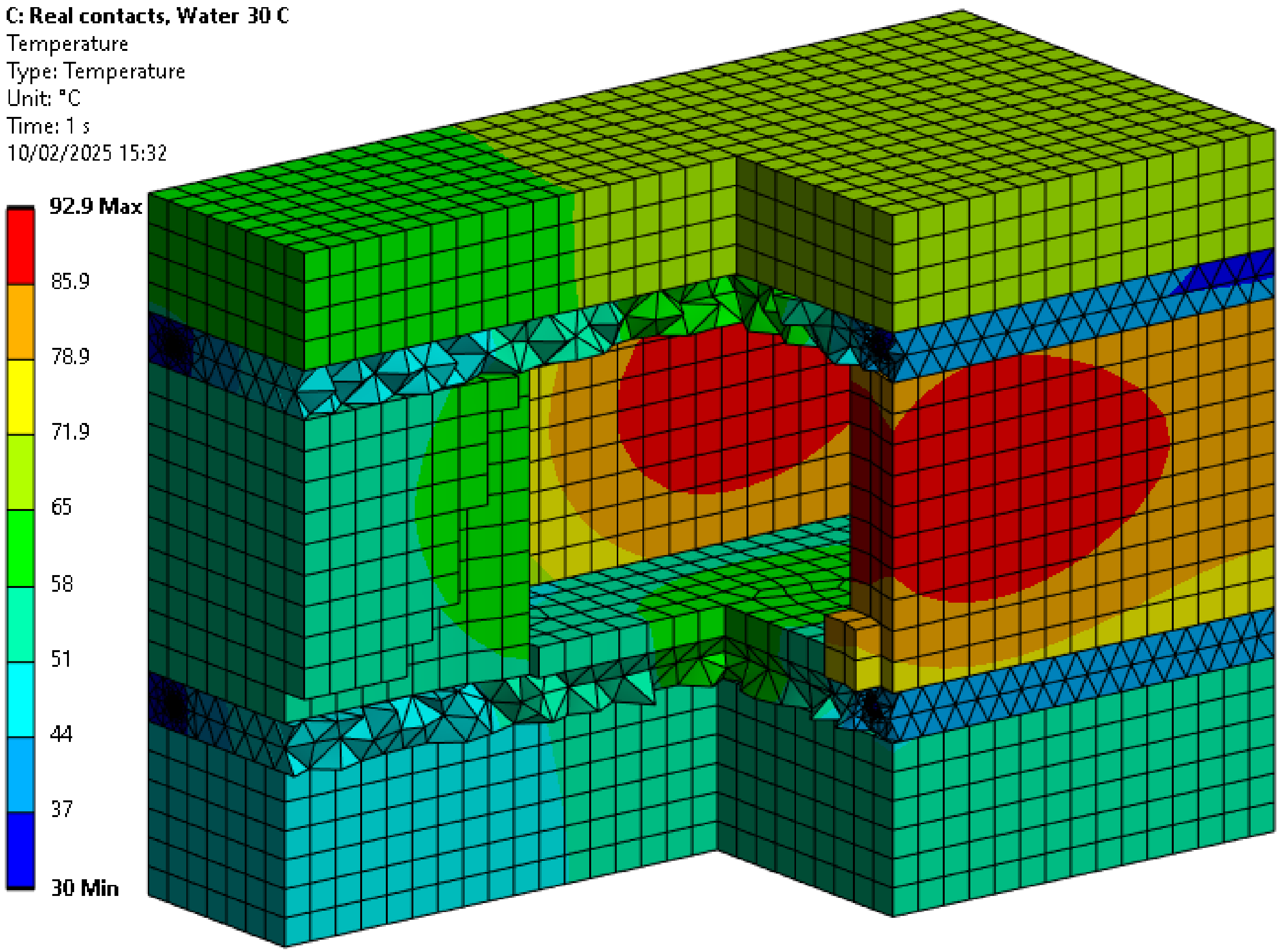




Simulations with FLUKA model: Water cooled top plate and bottom plate

- Added cooling plate top bottom

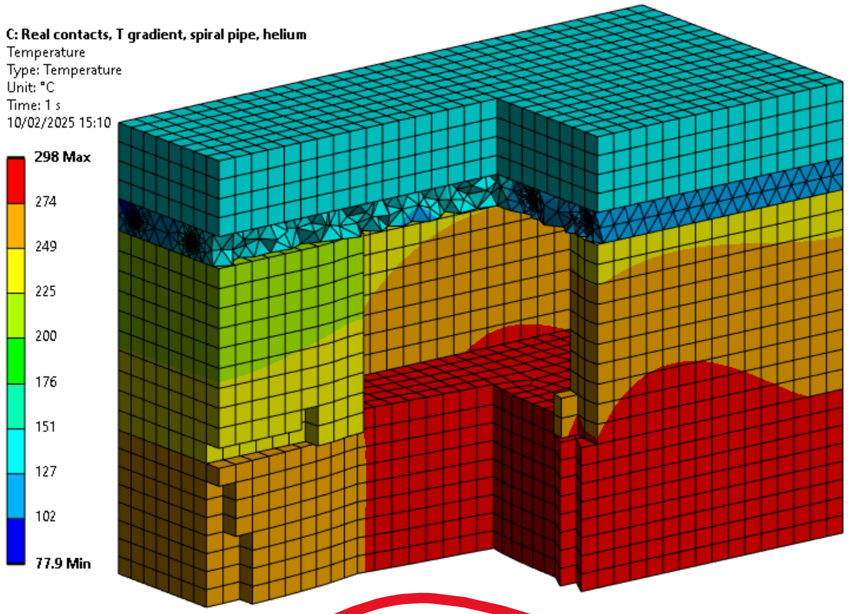
- Two pipes goes to the top, and two pipes to the bottom, all in the same circuit

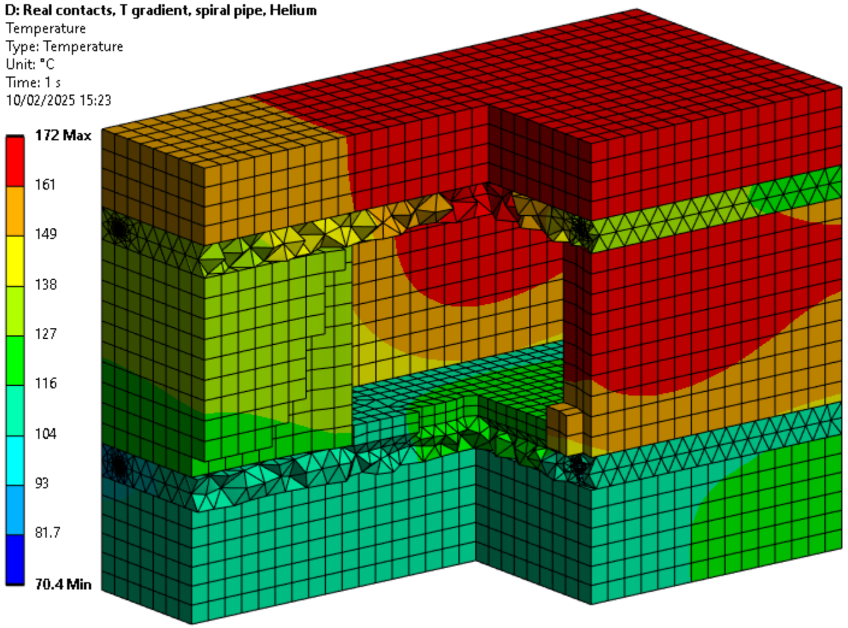


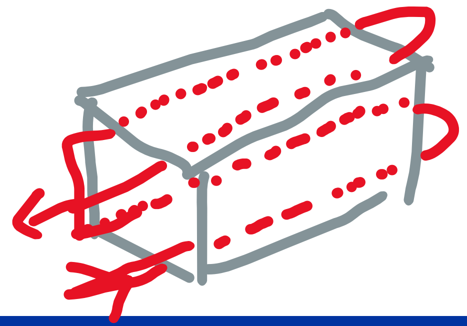
Simulations with FLUKA model: Helium cooled top and bottom plate

- **Assuming:**
  - Helium flow in cooling pipes is fully turbulent. At the inlet: 16 bar, 30 g/s, 20 C
  - Cooling plate on top is cast iron with stainless-steel pipes inside the cast. Perfect thermal conductivity.
  - Assumed real conductance calculated from CMY model.

- **Conclusion:**
  - Realistic thermal contact conductance is very low and affects the cooling performance severely.
  - Cooling performance can be increased with more contact pressure and/or a copper cooling plate





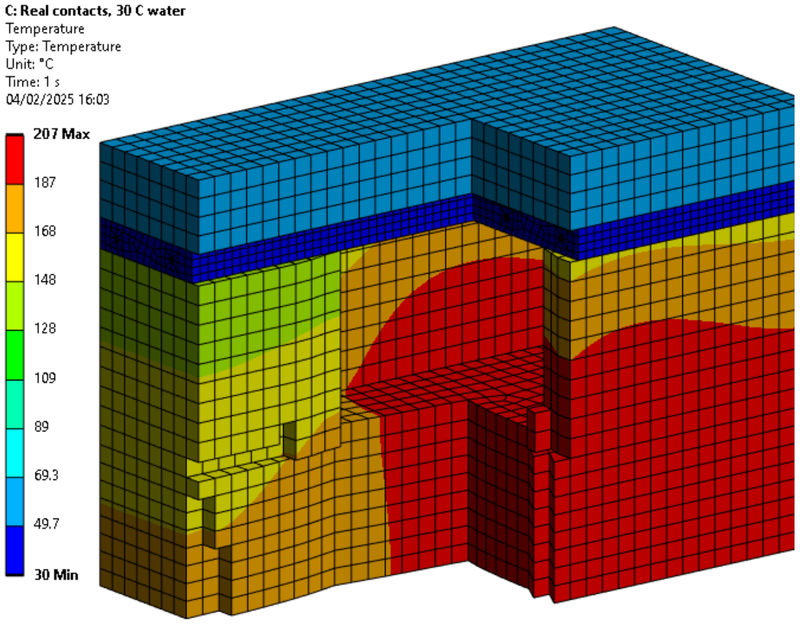


Water results:

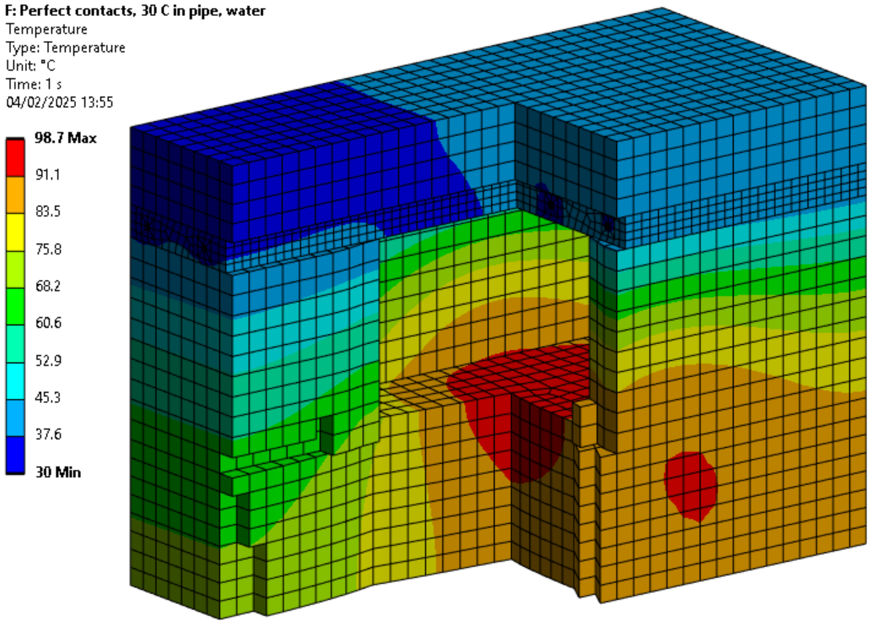
Figure	Cooling Medium	Coolant properties	Cooling circuit	Cooling plate	Materials	Thermal contacts	Max temp [C]	Min temp [C]
a	Water	Constant 30 C	Lateral	Top only	All cast iron	Perfect	98.7	30
b	Water	Constant 30 C	Lateral	Top only	All cast iron	Realistic	207	30
c	Water	Constant 30 C	Lateral	Top and bott	All cast iron	Realistic	92.9	30

Top cooling plate

a

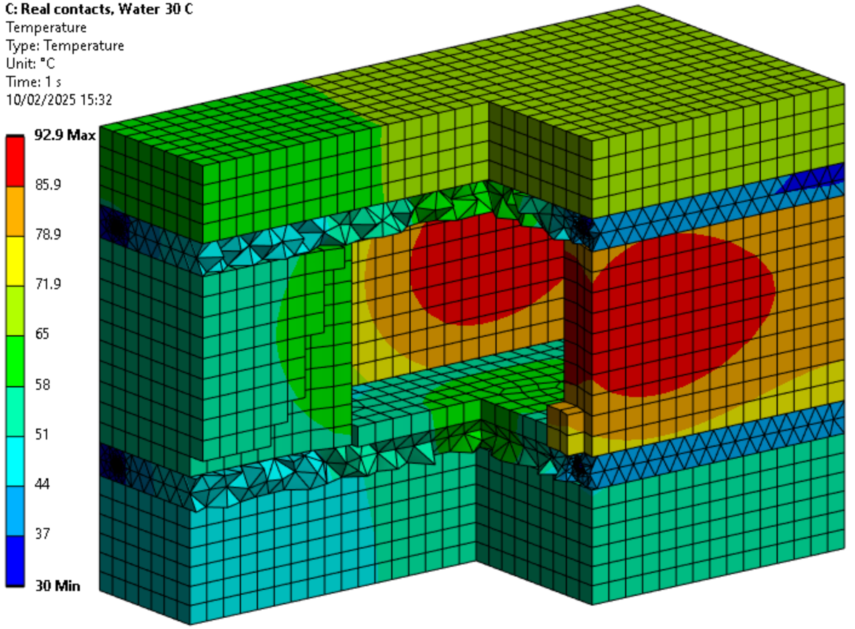


b



Top and bottom cooling plate

c

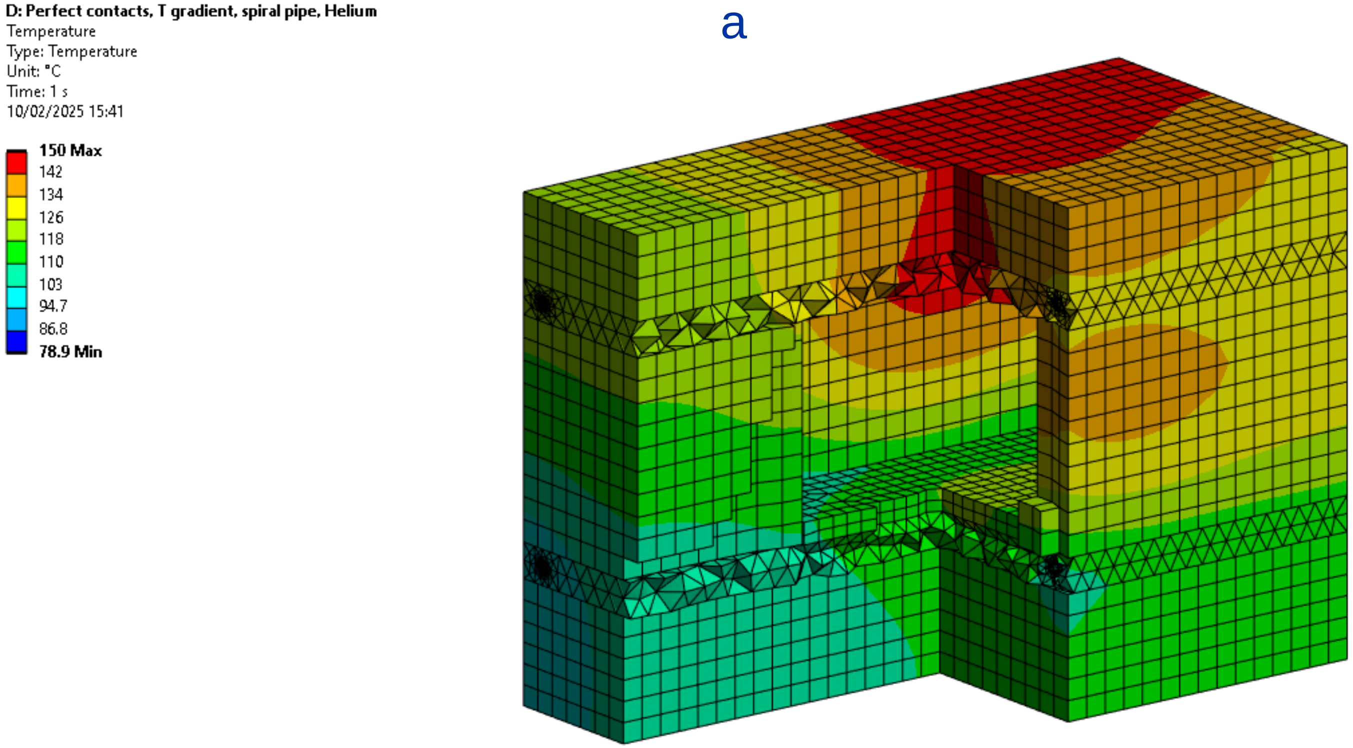


Perfect contacts with helium

Figure	Cooling Medium	Coolant properties	Cooling circuit	Cooling plate	Materials	Thermal contacts	Max temp [C]	Min temp [C]
a	Helium	30C inlet, +30C per pass	Lateral	Top and bottom	All cast iron	Perfect	150	78.9
b	Helium	30C inlet, +30C per pass	Lateral	Top only	All cast iron	Perfect	177	86.1

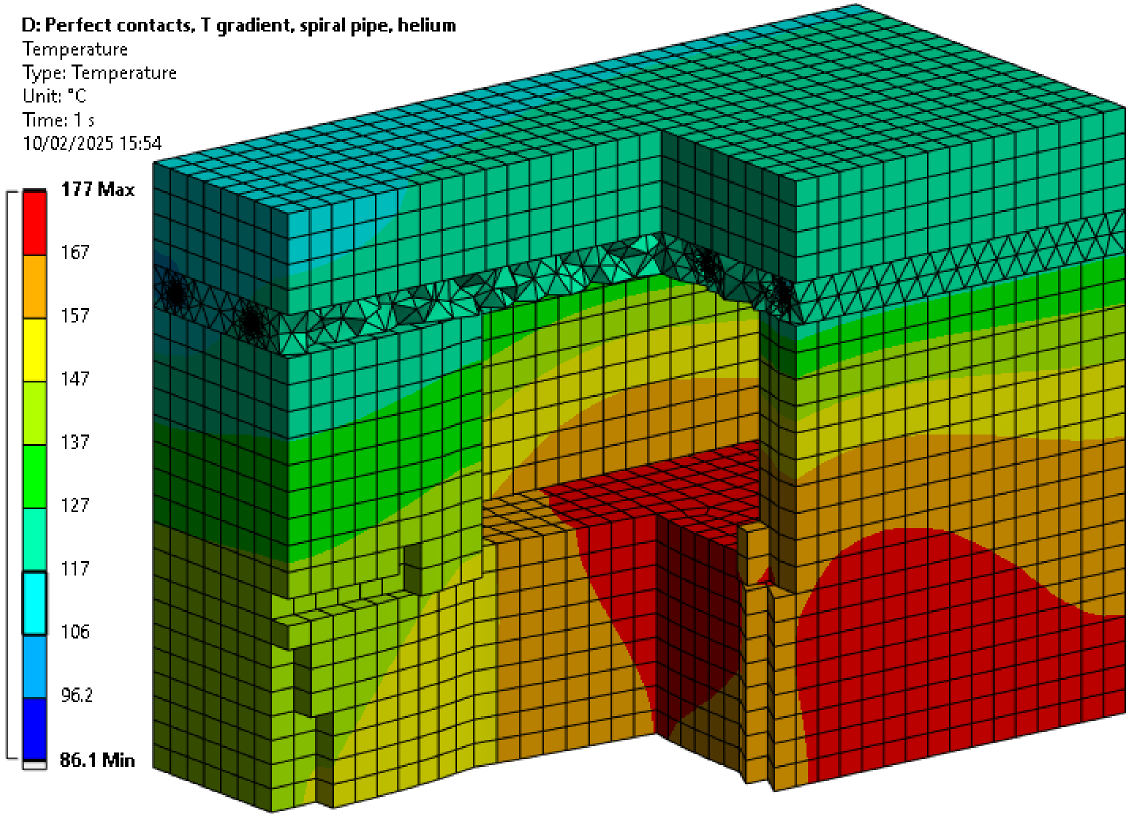
Top and bottom cooling plate

a



Top cooling plate

b



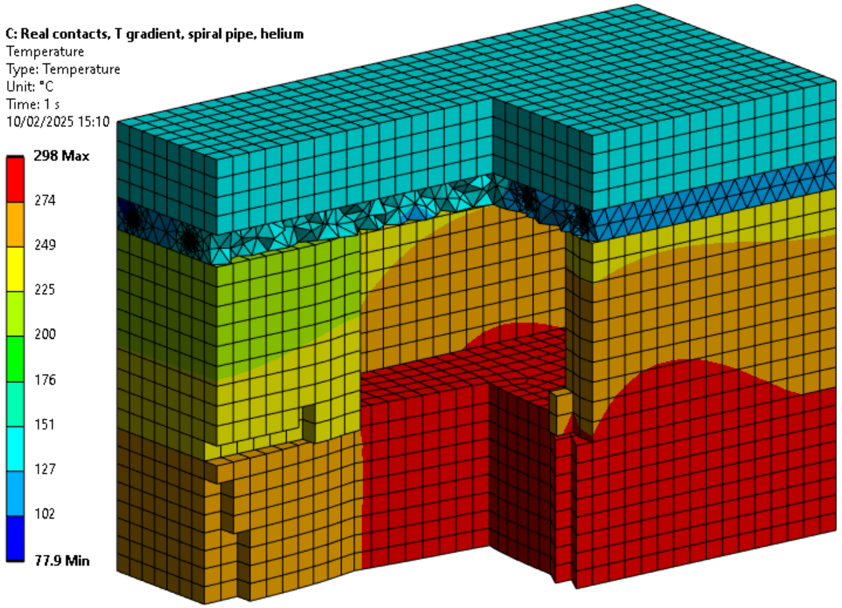
Real contacts helium

Figure	Cooling Medium	Coolant properties	Cooling circuit	Cooling plate	Materials	Thermal contacts	Max temp [C]	Min temp [C]
a	Helium	30C inlet, +30C per pass	Spiral	Top only	All cast iron	Realistic	298	77.9
b	Helium	30C inlet, +30C per pass	Lateral	Top only	All cast iron	Realistic	274	66.6
c	Helium	30C inlet, +30C per pass	Spiral	Top and bottom	All cast iron	Realistic	172	70.4

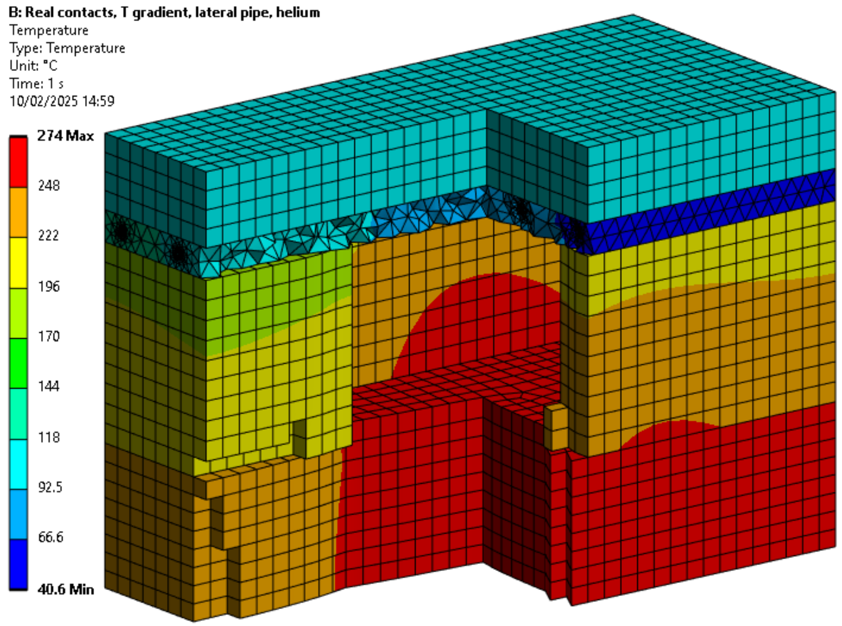
Top cooling plate

Top and bottom cooling plate

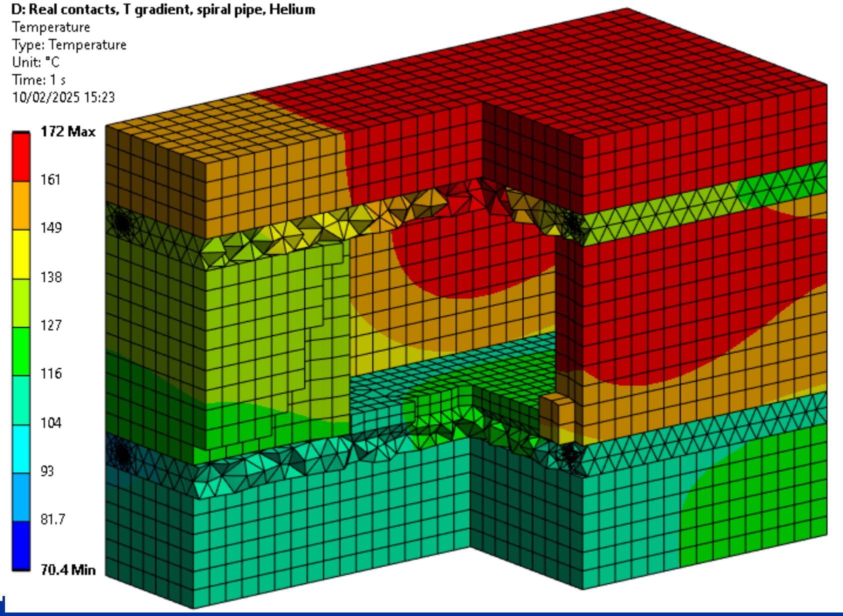
a



b



c



Findings compacted:

Cooling Medium	Coolant properties	Cooling circuit	Cooling plate	Materials	Thermal contacts	Max temp [C]	Min temp [C]
Helium	30C inlet, +30C per pass	Spiral	Top only	All cast iron	Realistic	298	77.9
Helium	30C inlet, +30C per pass	Lateral	Top only	All cast iron	Realistic	274	66.6
Water	Constant 30 C	Lateral	Top only	All cast iron	Realistic	207	30
Helium	30C inlet, +30C per pass	Spiral	Top only	All cast iron	Perfect	177	86.1
Helium	30C inlet, +30C per pass	Spiral	Top and bottom	All cast iron	Realistic	172	70.4
Helium	30C inlet, +30C per pass	Spiral	Top and bottom	All cast iron	Perfect	150	78.9
Water	Constant 30 C	Lateral	Top only	All cast iron	Perfect	98.7	30
Water	Constant 30 C	Lateral	Top and bottom	All cast iron	Realistic	92.9	30

Future work

- **Studies with copper plate to improve thermal contact conductance to cooling plate**
- **Studies with different shielding cut configurations**
- **Studies with new ST model**

- **Integration is fine with all copper for shielding**
  - Studies with this as well. Should improve cooling performance considerably
- **Integration wants to reduce the number of inlets and coolant connections**
  - Investigate implementing cooling middle block

home.cern