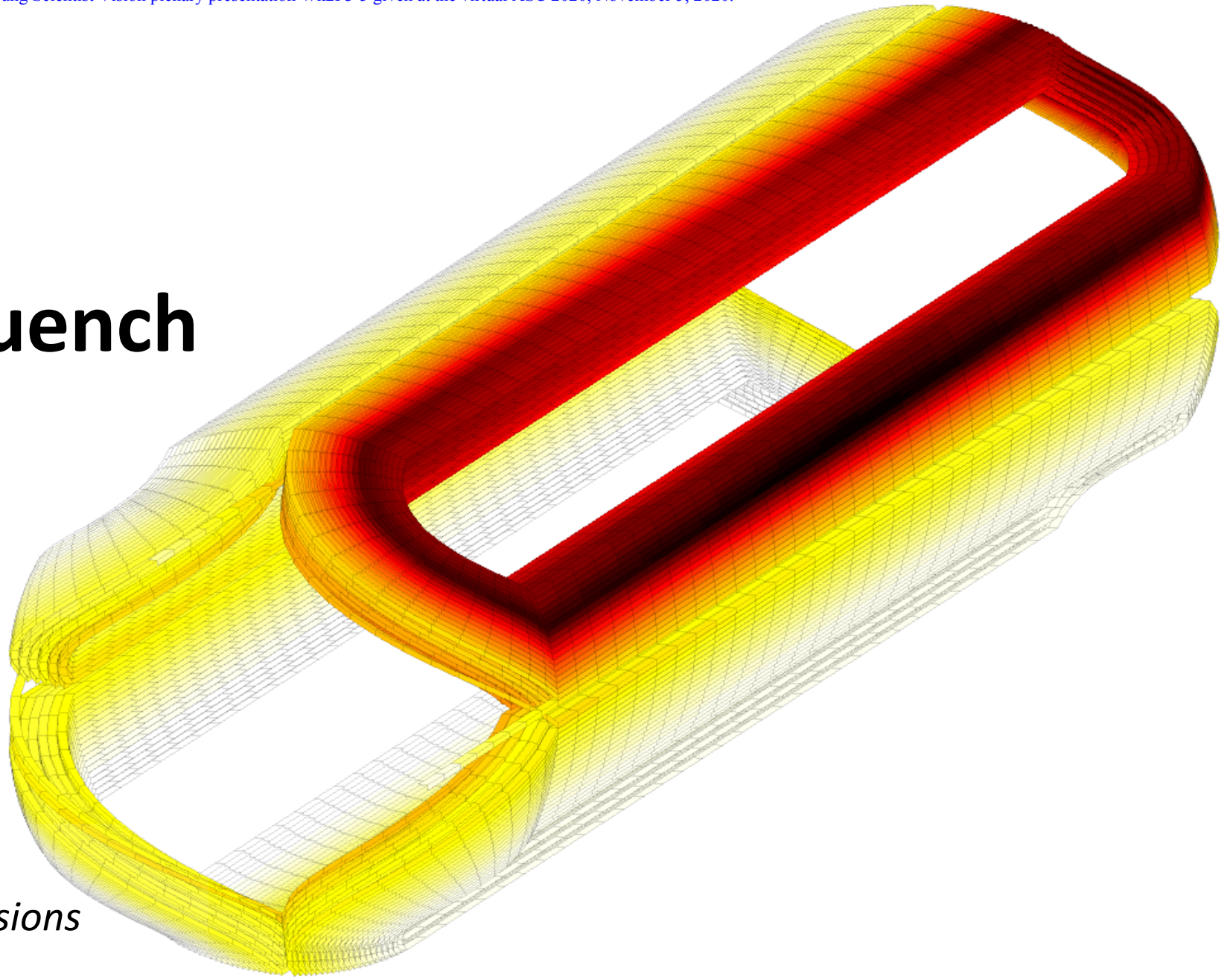
IEEE CSC & ESAS SUPERCONDUCTIVITY NEWS FORUM (global edition), No. 49, March 2021.
Young Scientist Vision plenary presentation Wk2P3-5 given at the virtual ASC 2020, November 5, 2020.

Simulating a 3D magnet quench in 7 minutes

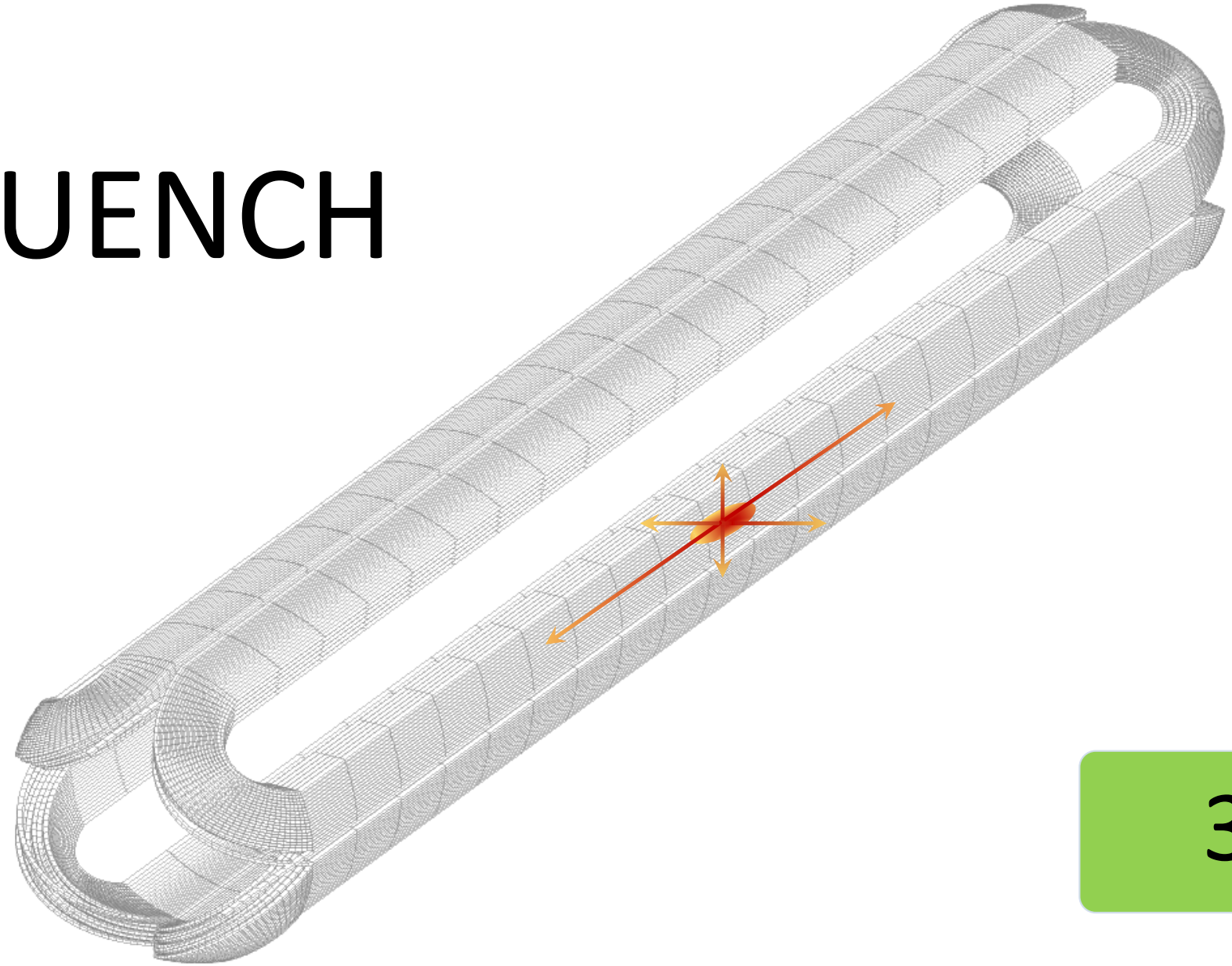


Emmanuele Ravaioli

5 November 2020

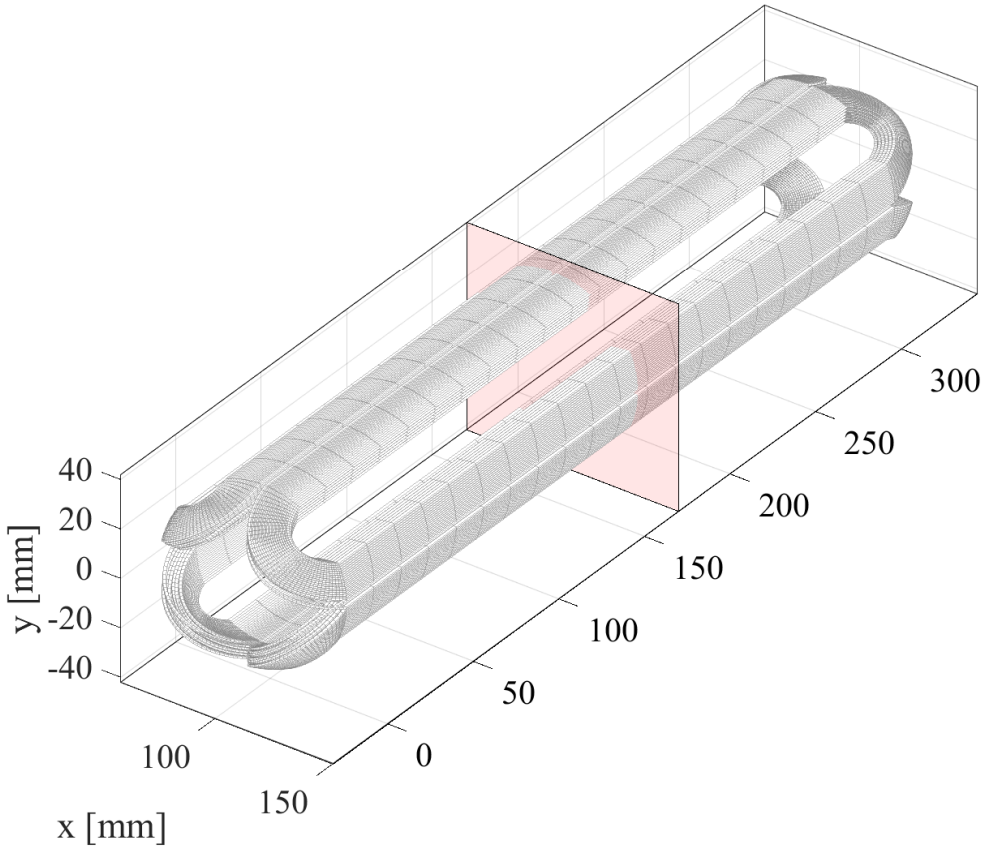
ASC2020 Young Scientist Visions

QUENCH

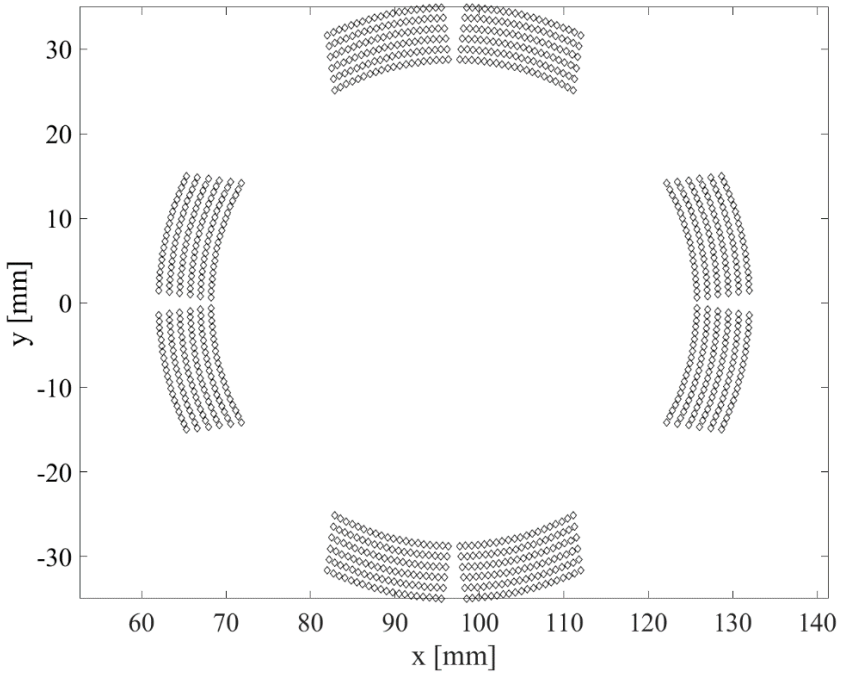


3D

3D


40
20
0
-20
-40
y [mm]
100
150
x [mm]
0
50
100
150
200
250
300

2D


30
20
10
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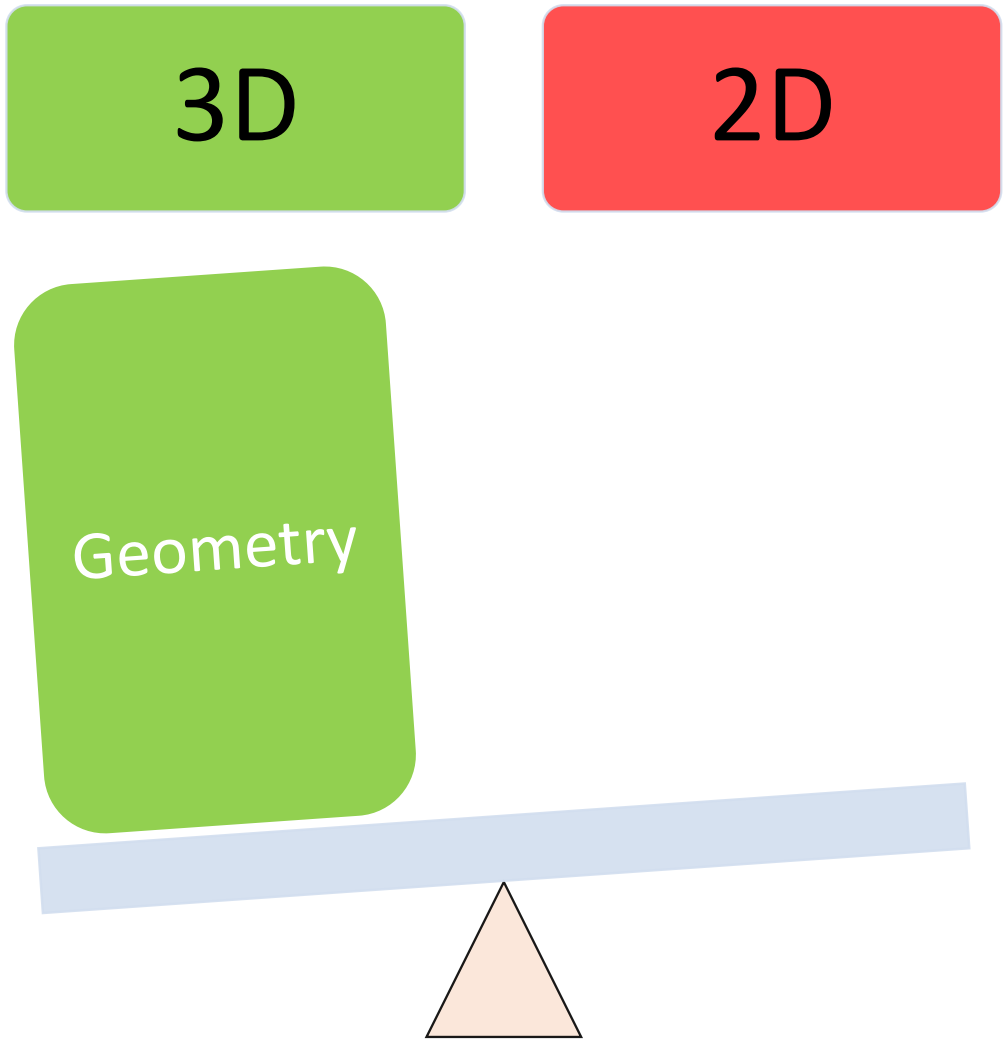
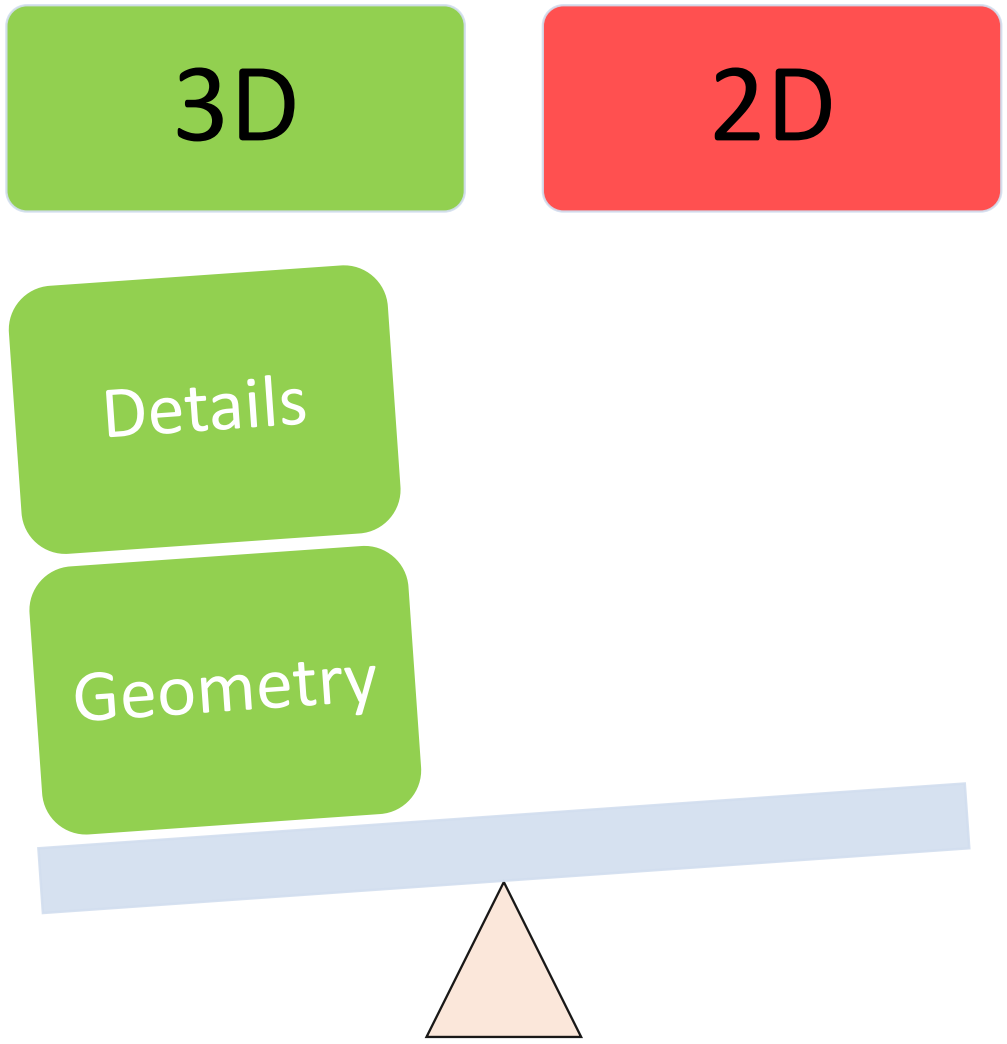
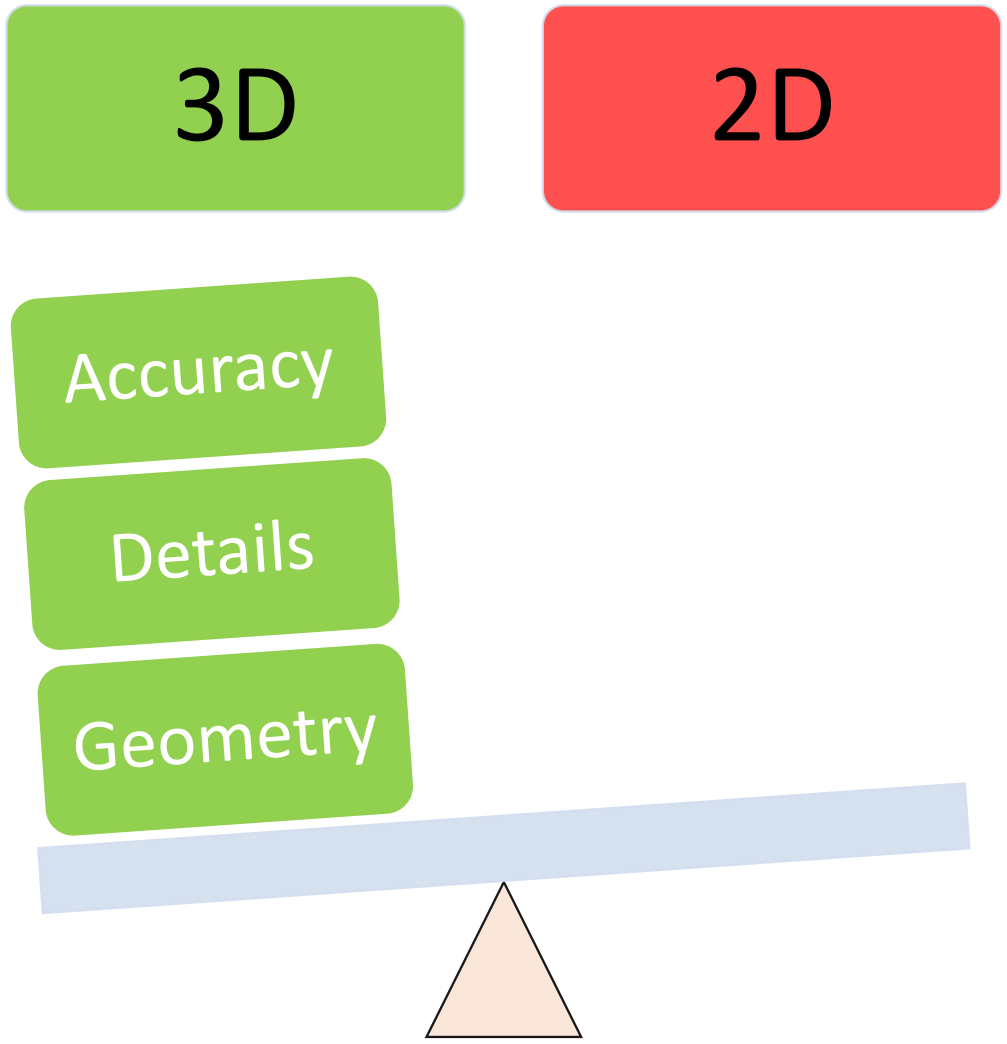
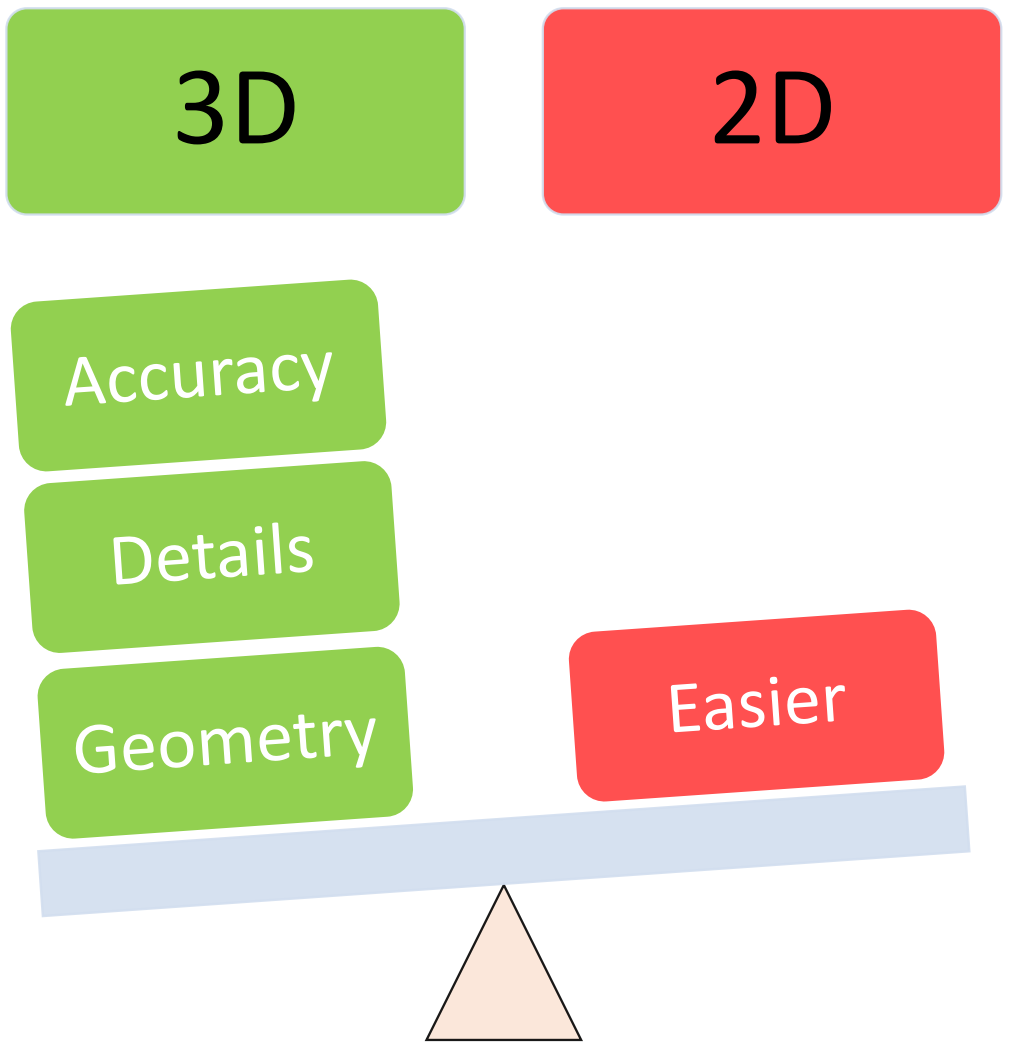
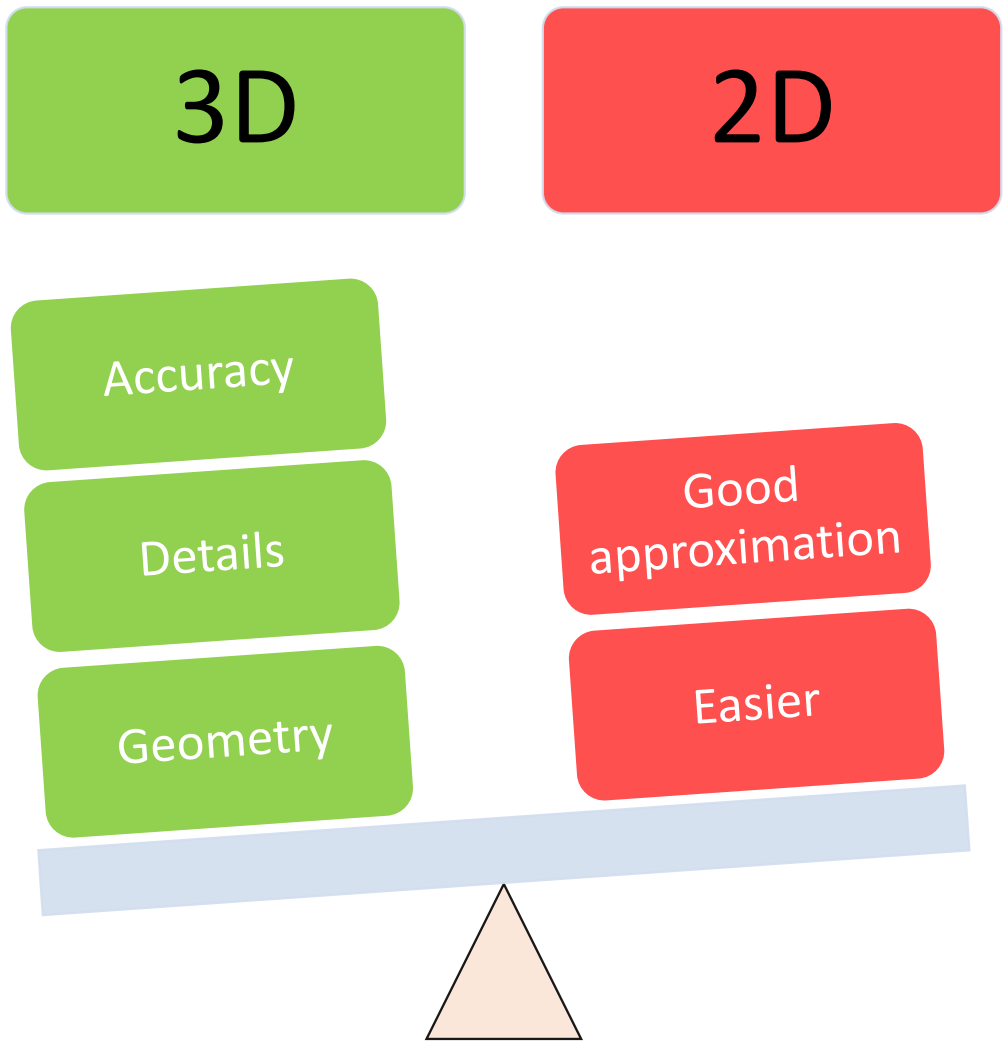
-10
-20
-30
y [mm]
60
70
80
90
100
110
120
130
140
x [mm]

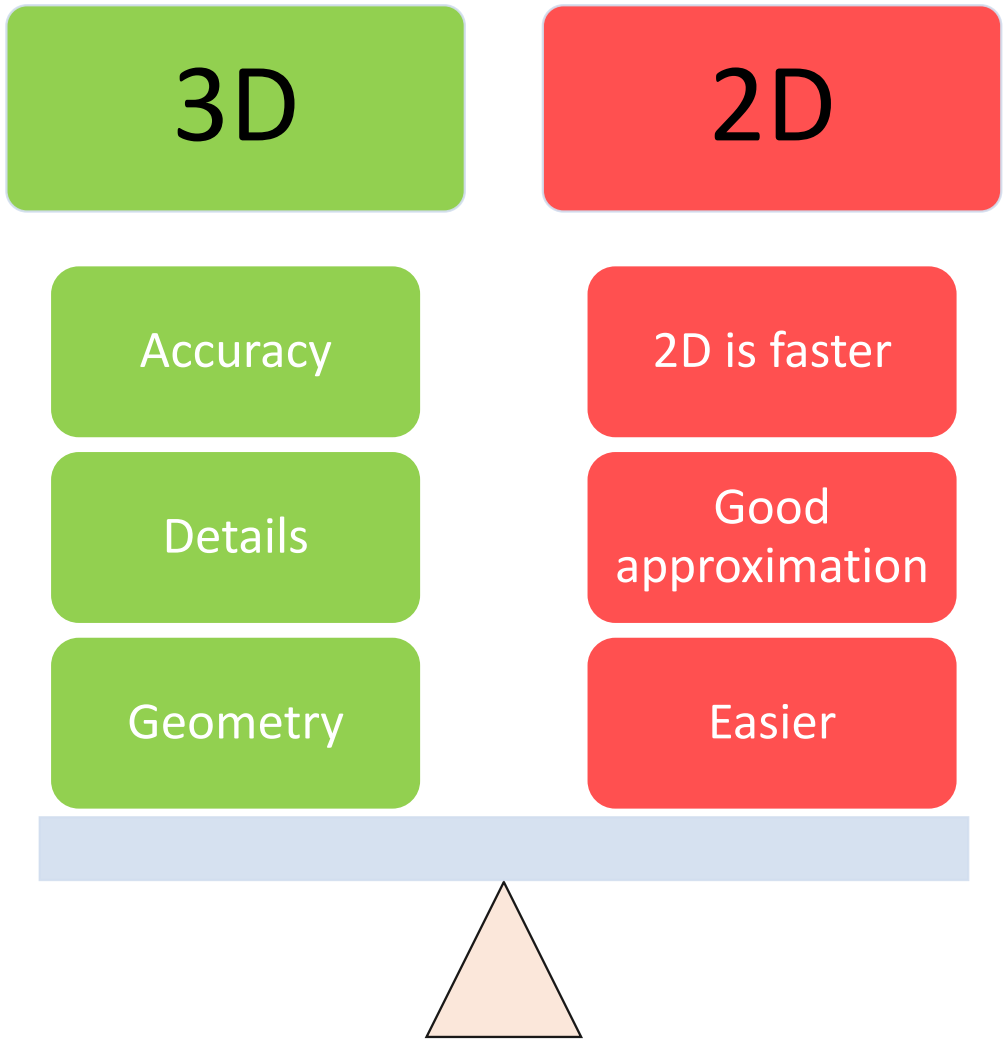

3D
2D
Geometry

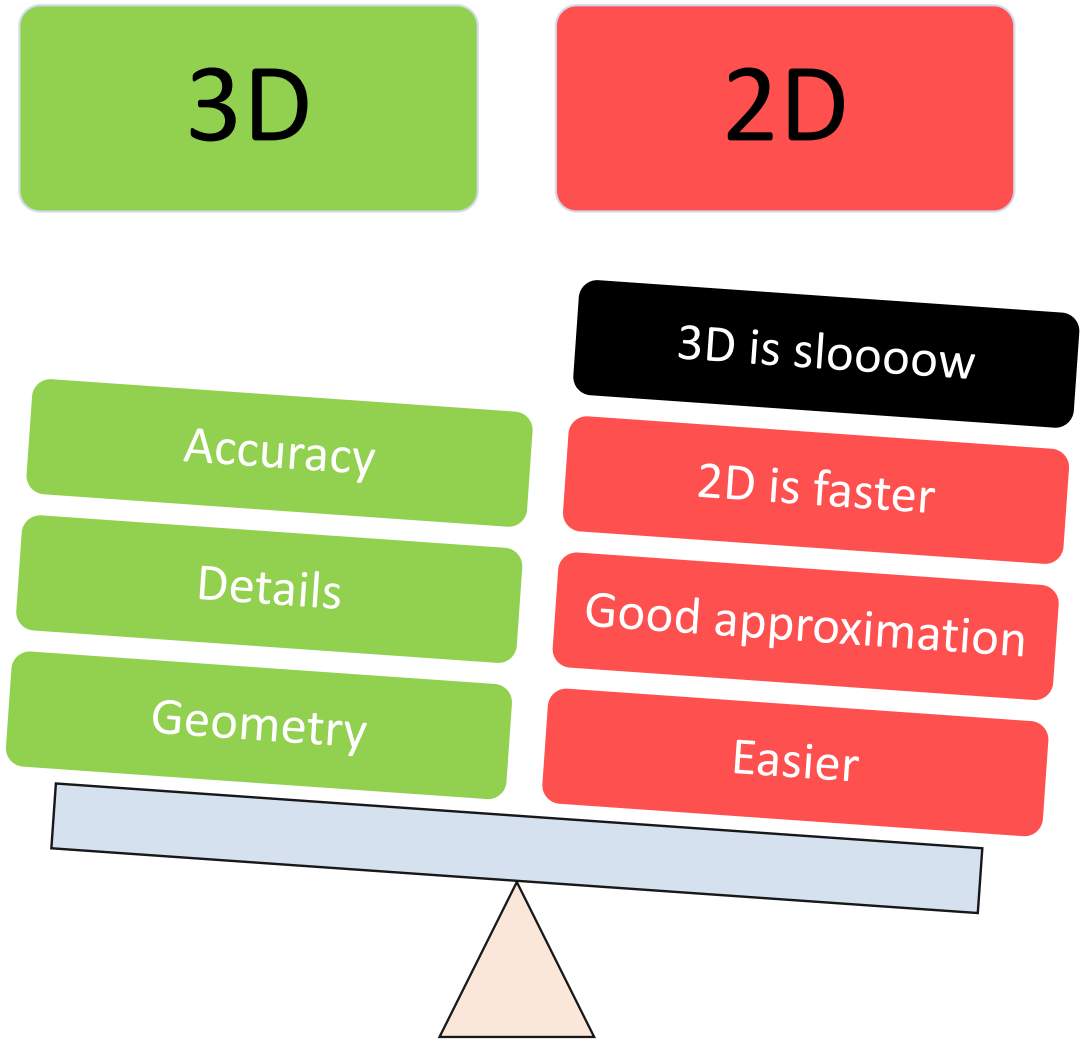

3D
2D
Details
Geometry


3D
2D
Accuracy
Details
Geometry


3D
2D
Accuracy
Details
Geometry
Easier


3D
2D
Accuracy
Details
Geometry
Good approximation
Easier


3D
2D
Accuracy
Details
Geometry
2D is faster
Good approximation
Easier


3D
2D
3D is sloooow
Accuracy
2D is faster
Details
Good approximation
Geometry
Easier

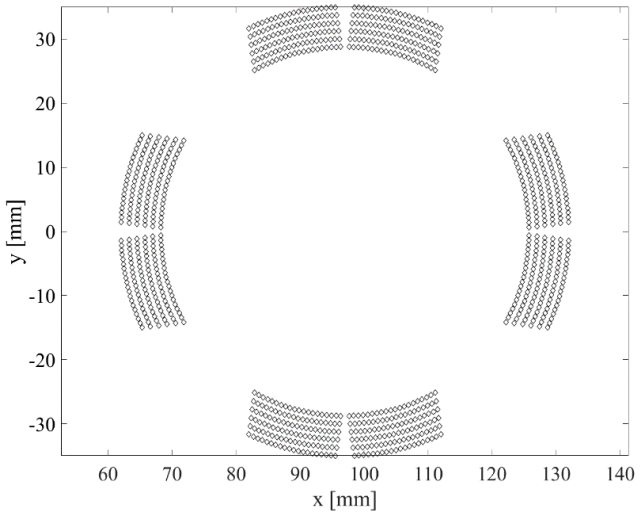
3D SIMULATIONS ARE

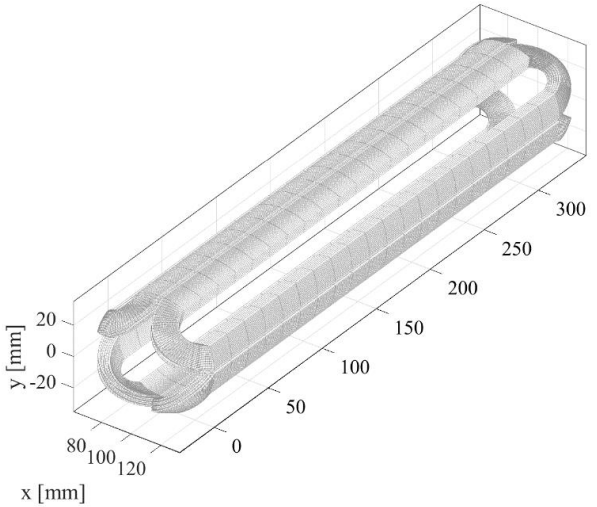
SLOW

3D SIMULATIONS ARE

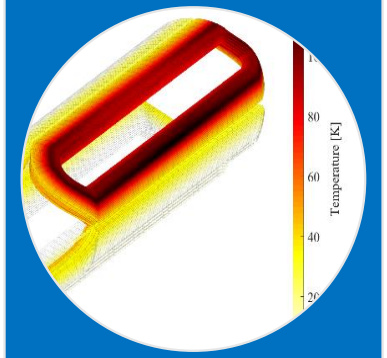
~~SLOW~~ *cool*

TODAY'S CHALLENGE

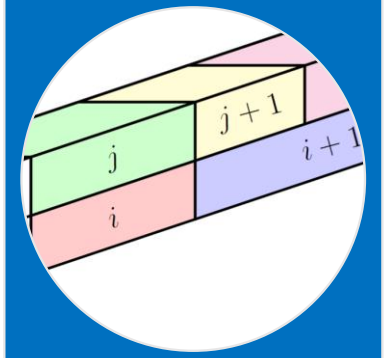




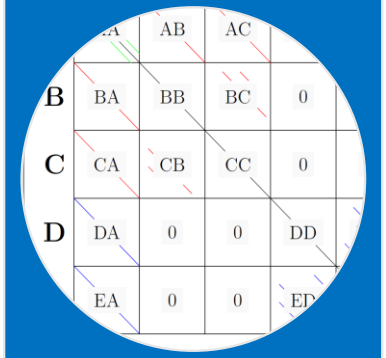
	2D	3D
Number of turns	480	480
Magnetic length	0.32 m	0.32 m
Total conductor length	-	360 m
Min/Max longitudinal spatial resolution	-	~1 mm / ~10 mm
Number of model elements	2*480	~250,000
Number of time points	~250	~250
Min/Max time resolution	~0.1 ms / ~10 ms	~0.1 ms / ~10 ms
Simulation time [with i5-6500 CPU 3.2 GHz]	<3 minutes	<10 minutes



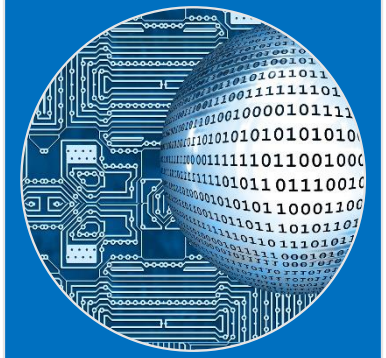
Physics of the problem



Assumptions Simplifications

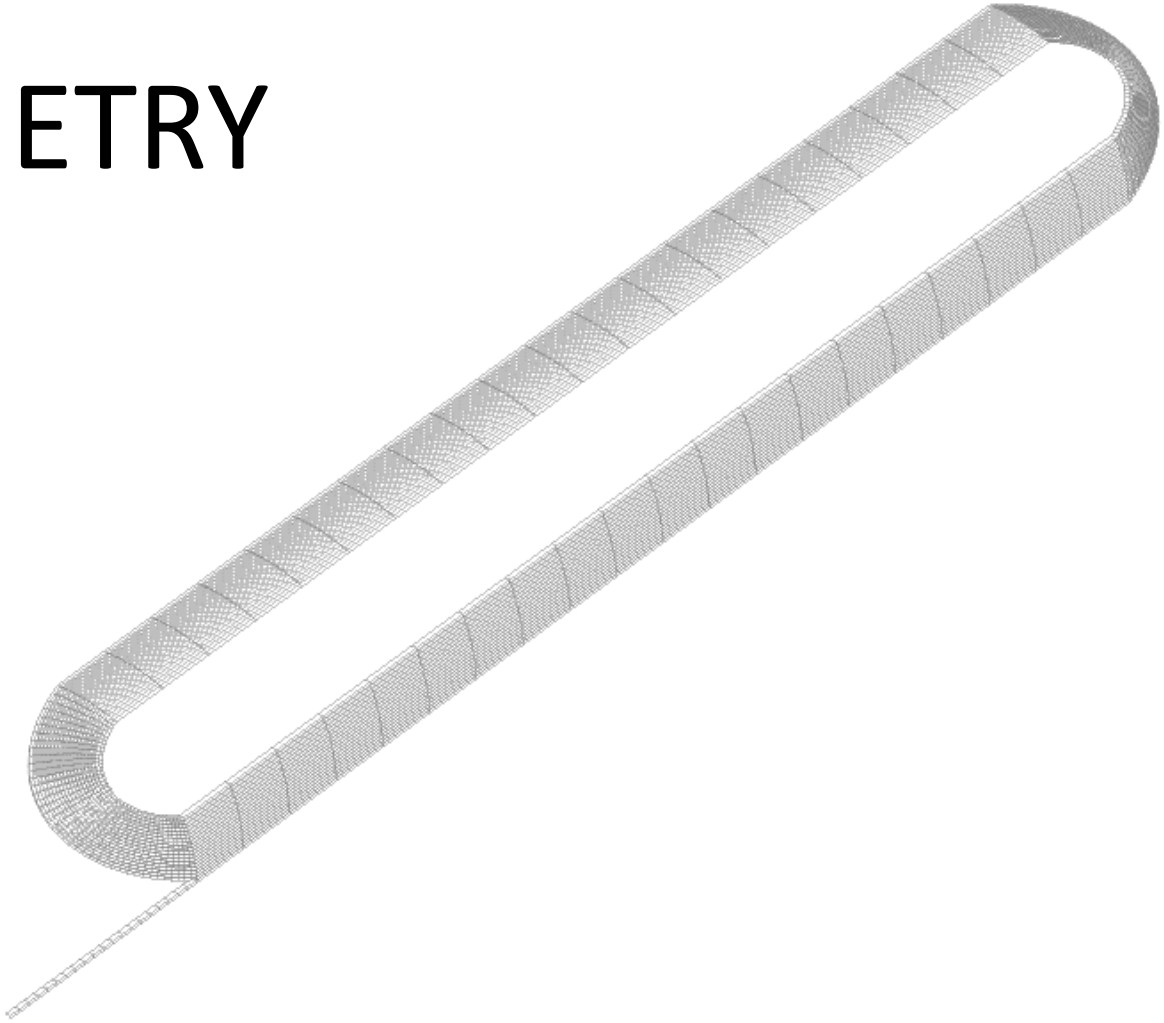


Numerical implementation

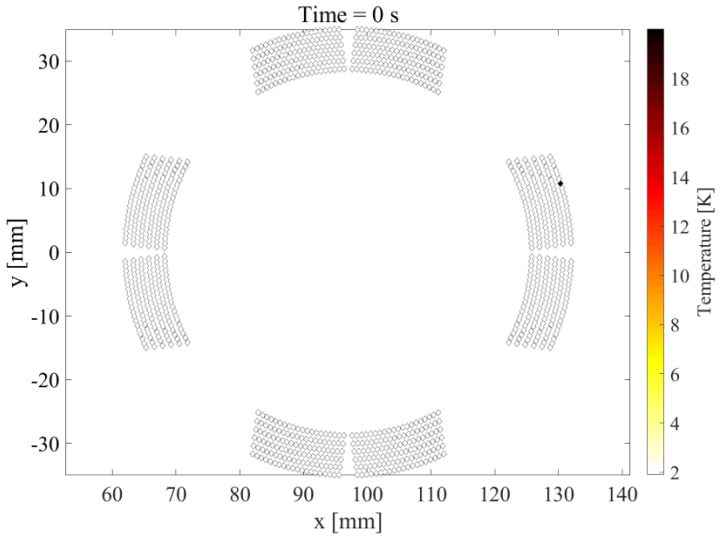


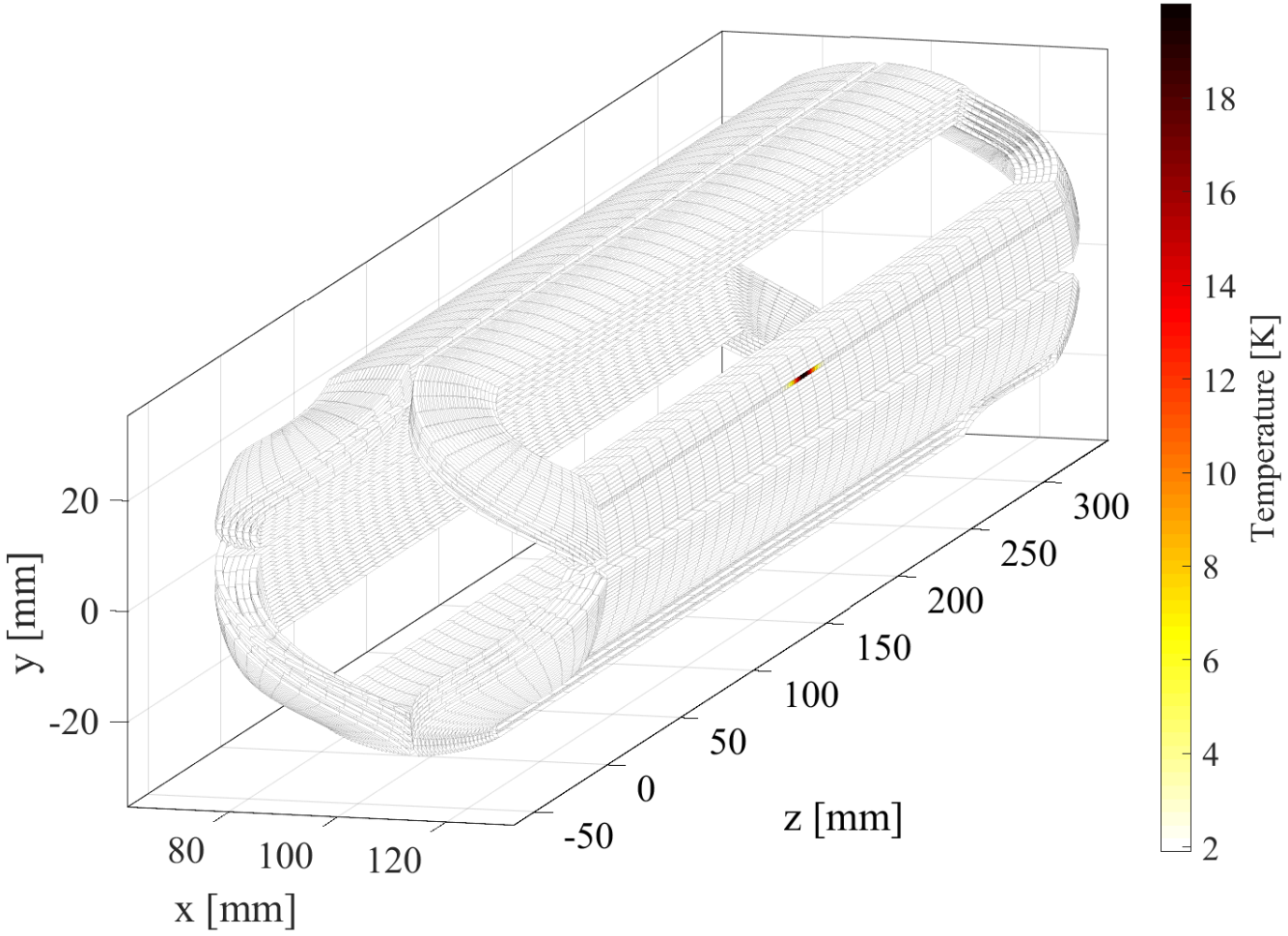
CPU / RAM

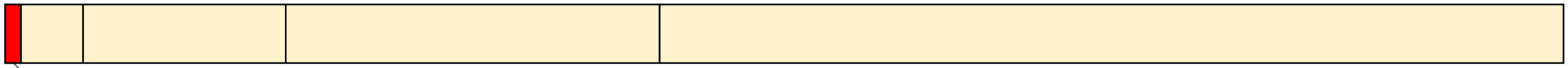
3D GEOMETRY



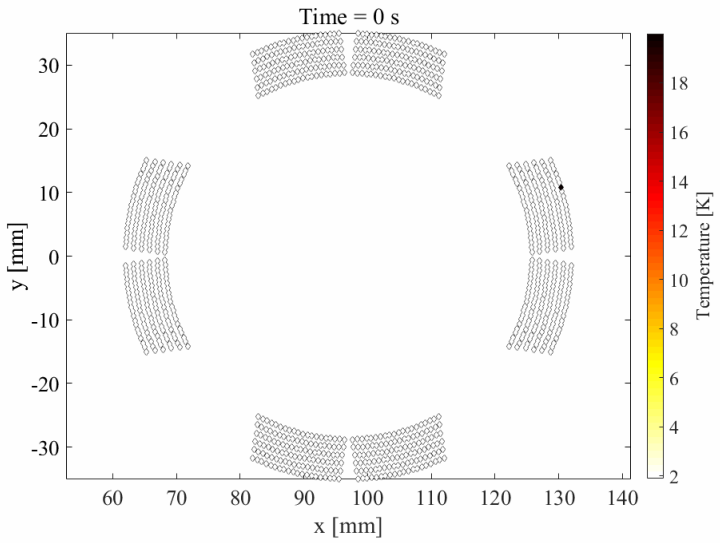
QUENCH STARTS

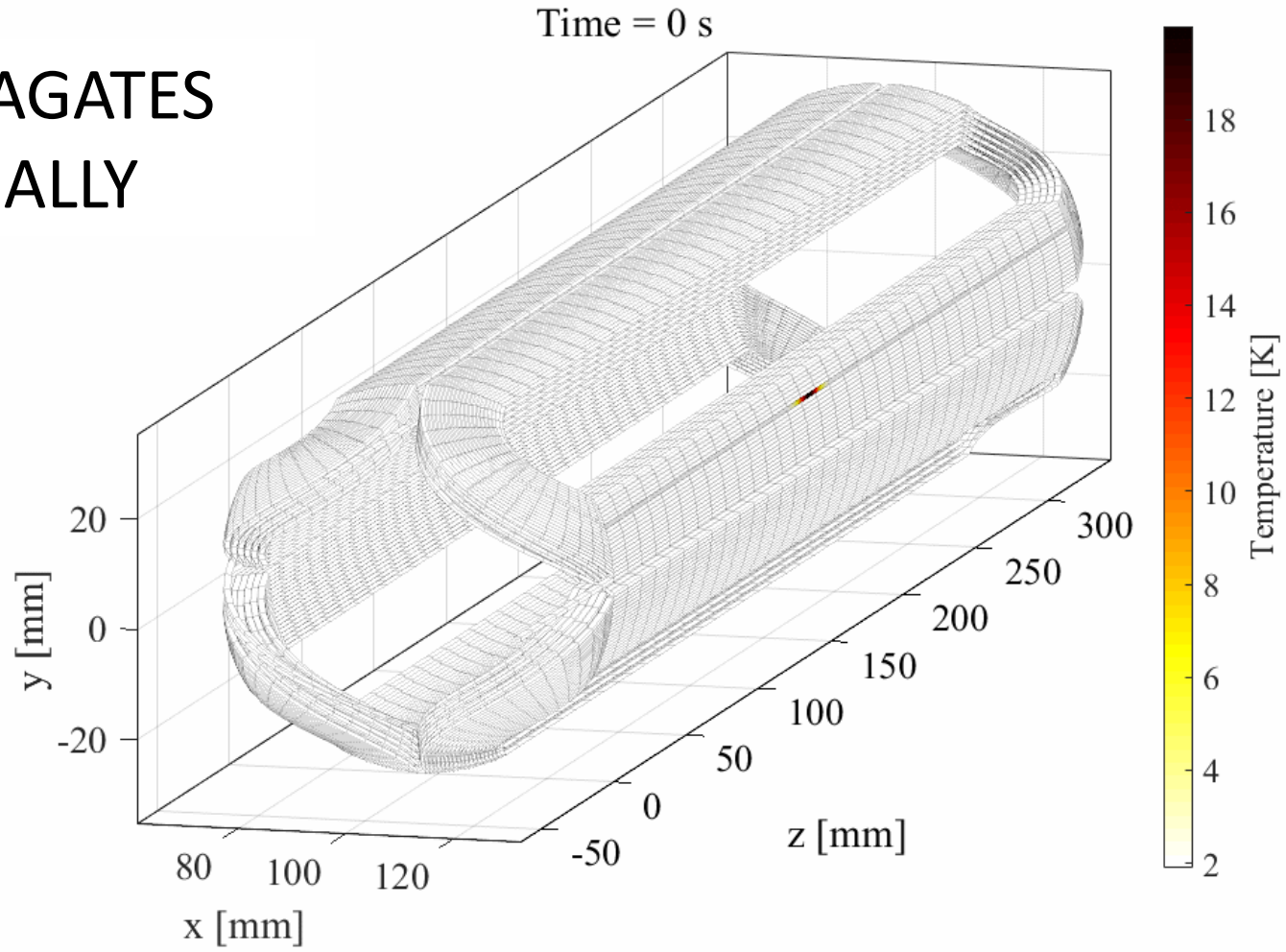


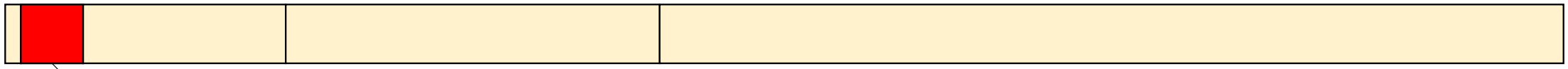




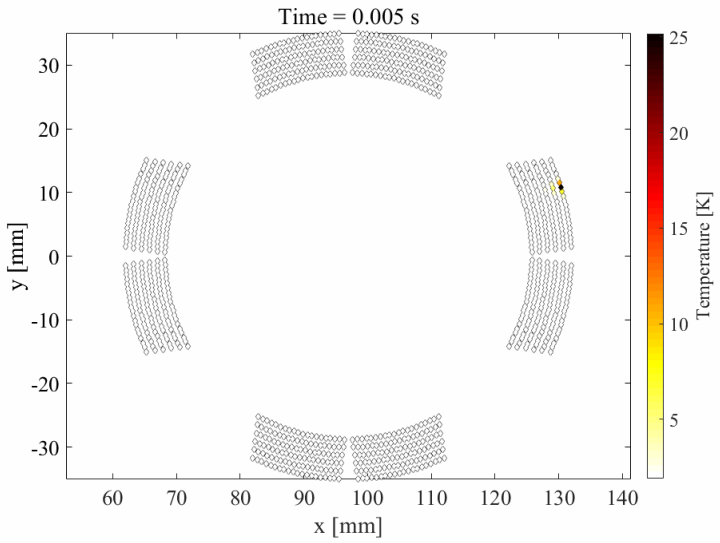
QUENCH PROPAGATES LONGITUDINALLY

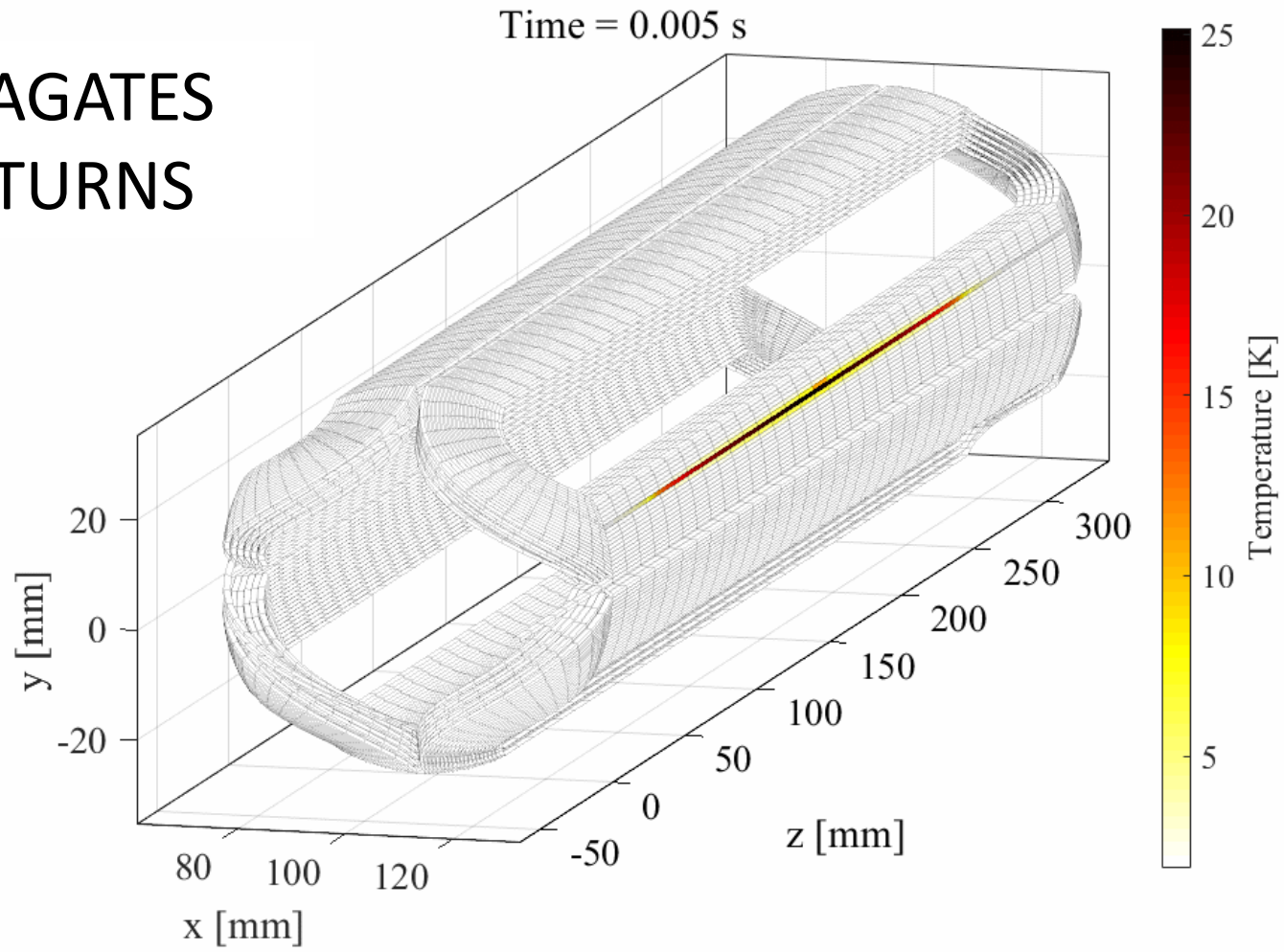


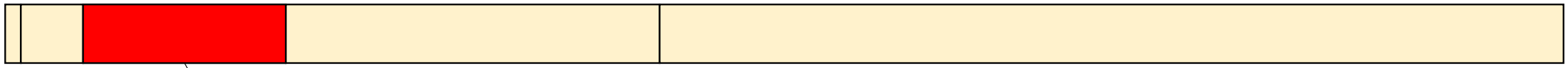




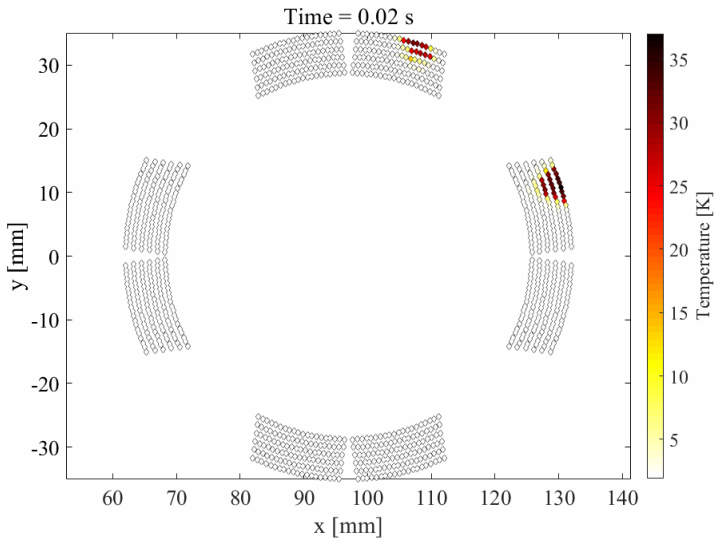
QUENCH PROPAGATES TO ADJACENT TURNS

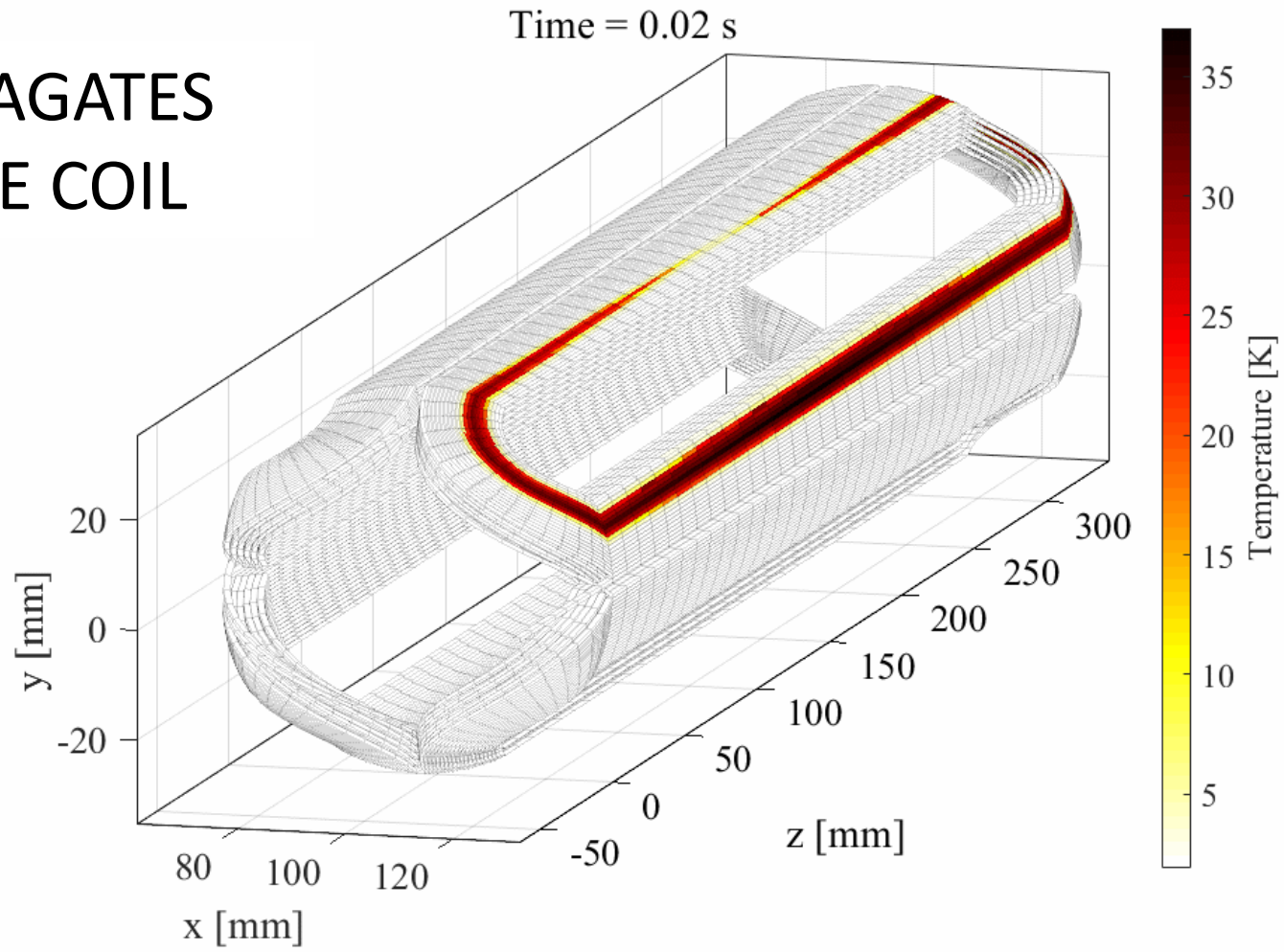


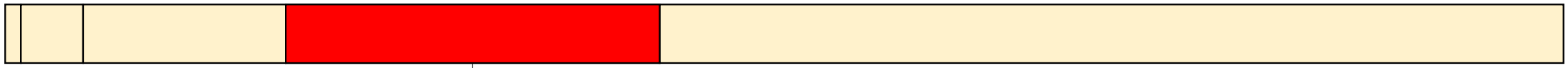




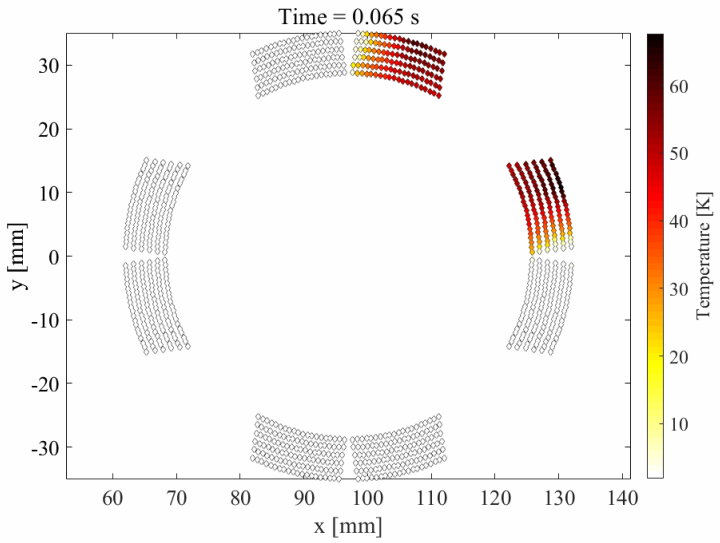
QUENCH PROPAGATES TO ONE ENTIRE COIL

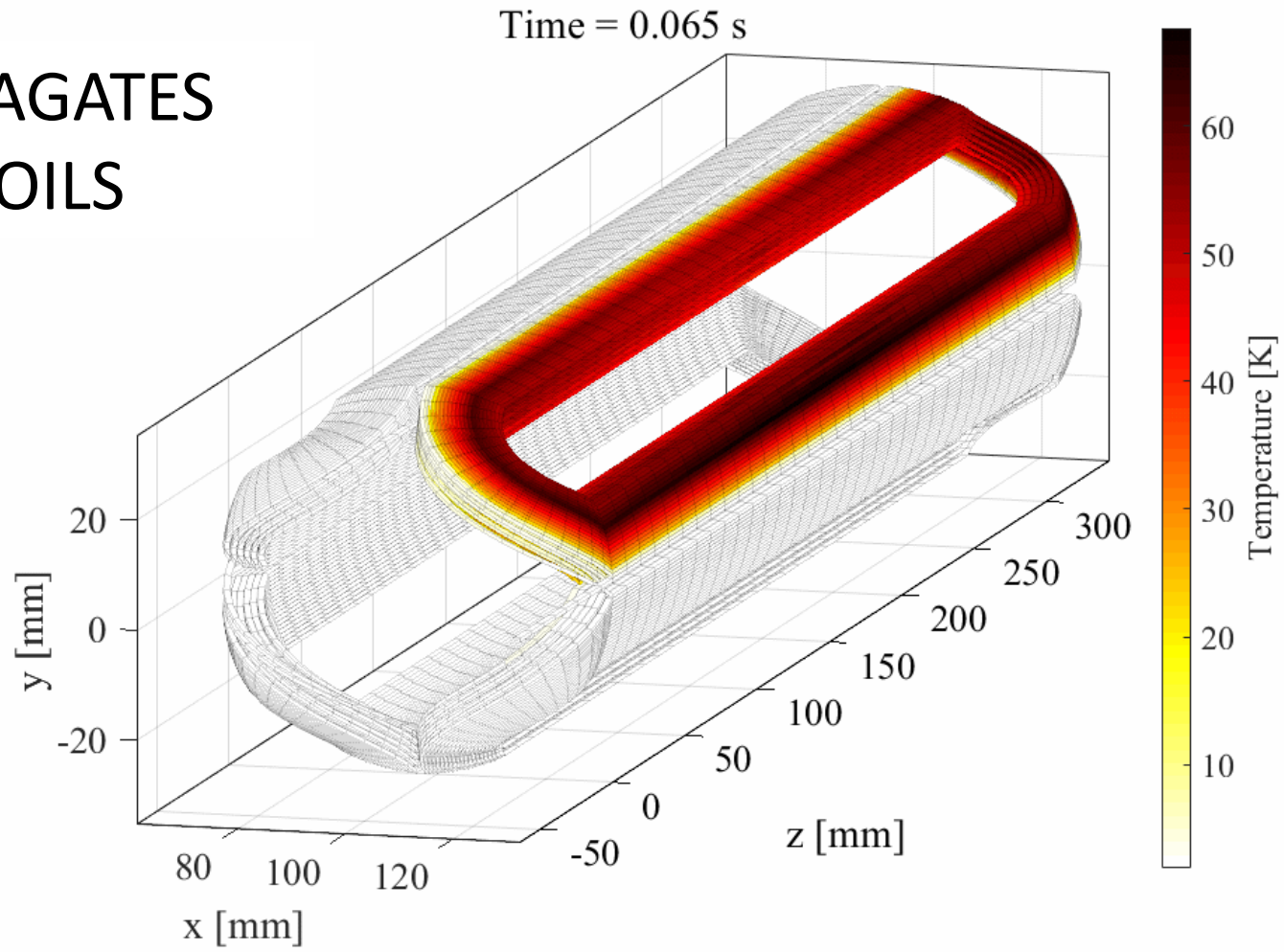






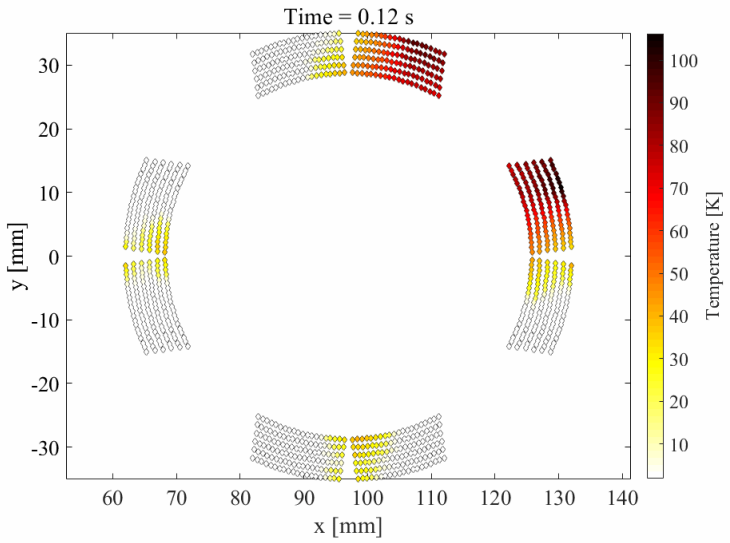
QUENCH PROPAGATES TO OTHER COILS

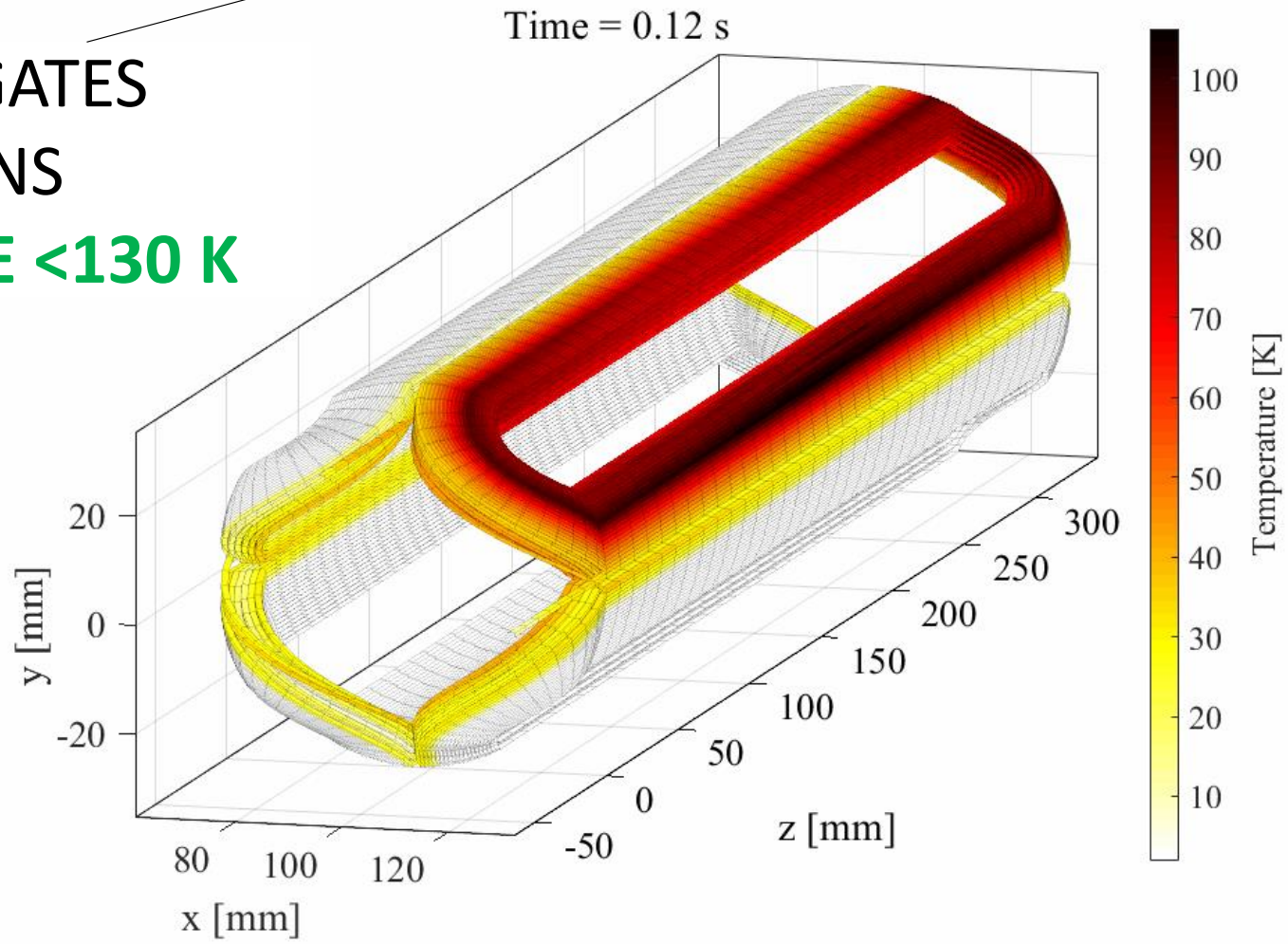




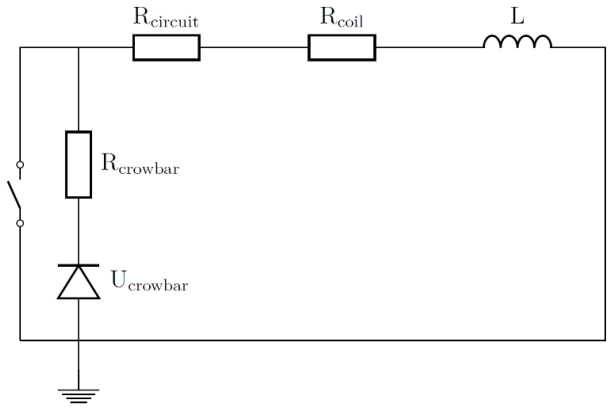
QUENCH PROPAGATES TO MOST TURNS

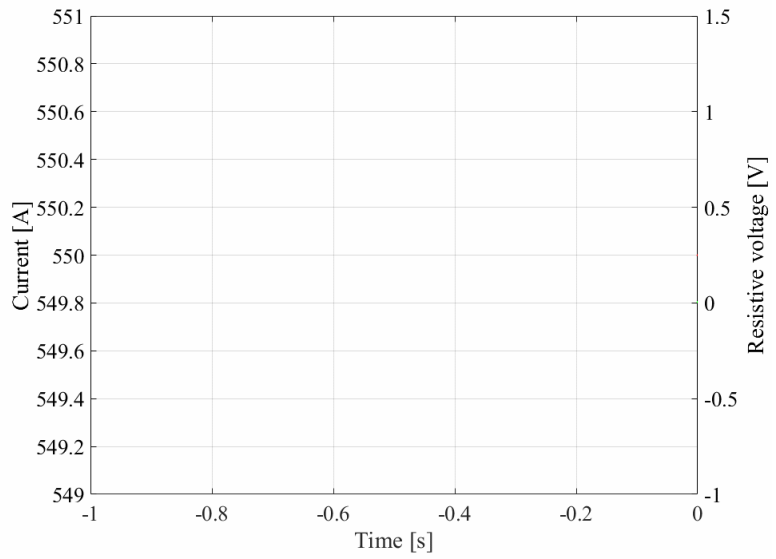
PEAK TEMPERATURE <130 K

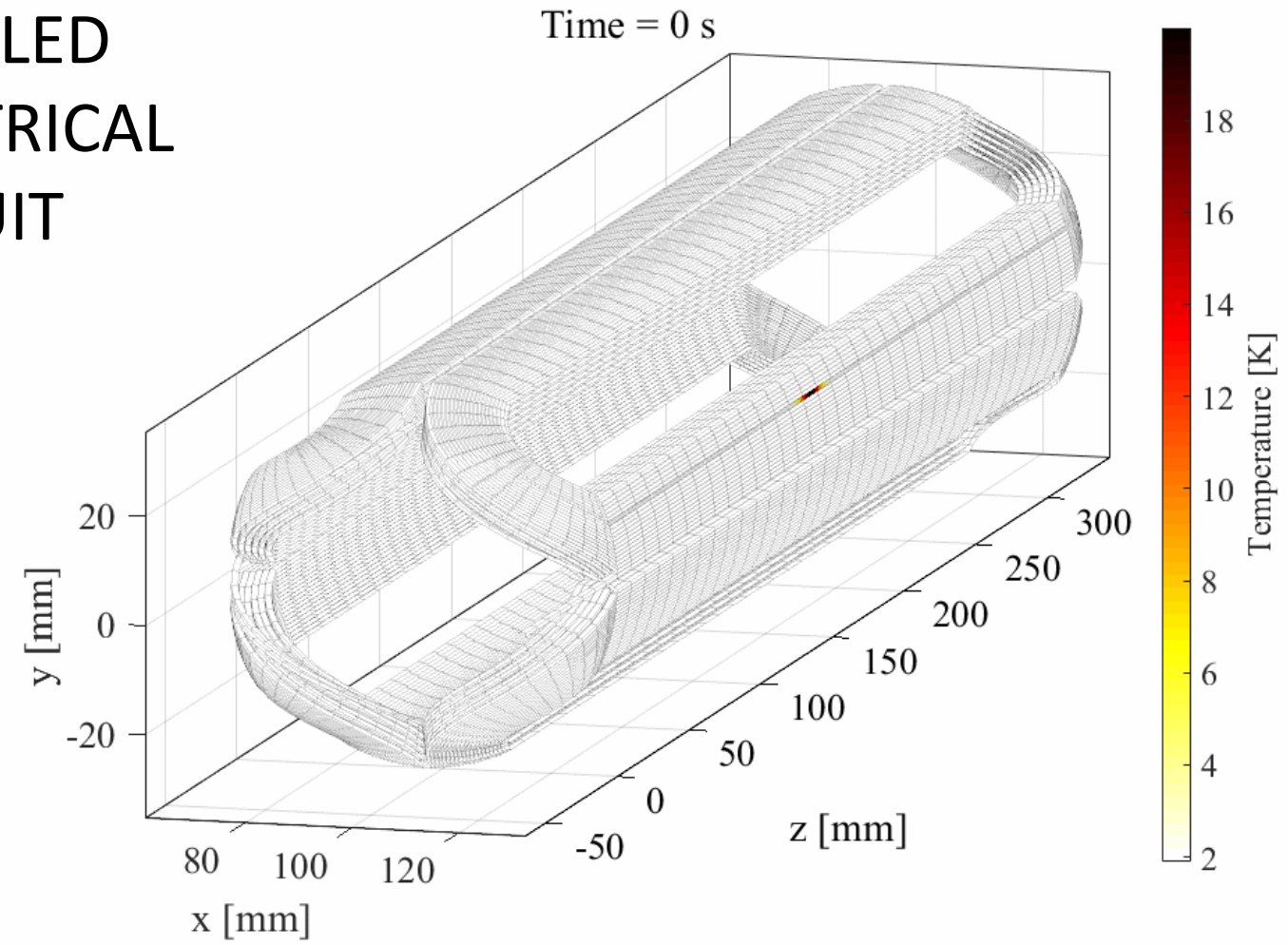


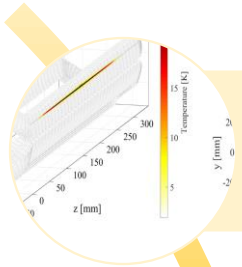


COUPLED ELECTRICAL CIRCUIT

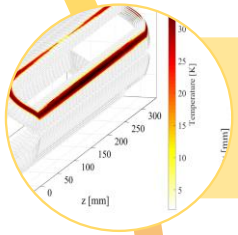




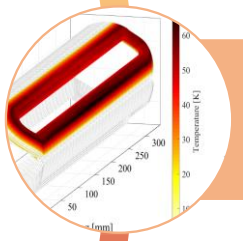




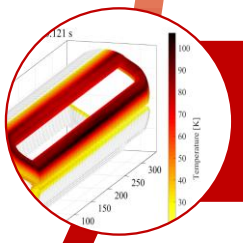
3D simulation of a quench



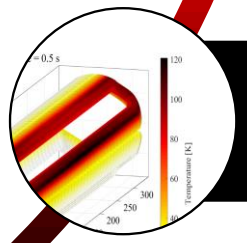
Applied to full-scale magnet



Very fast simulation (<10 minutes!)



Simple to model different magnets



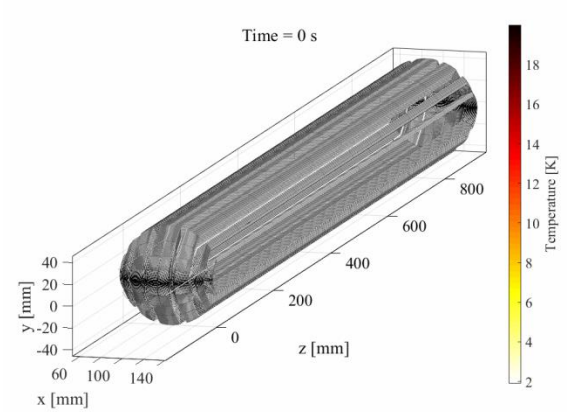
The program is easy to use… and free!

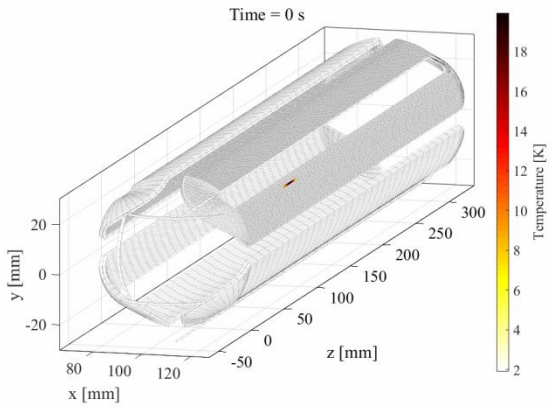
DRAWBACK

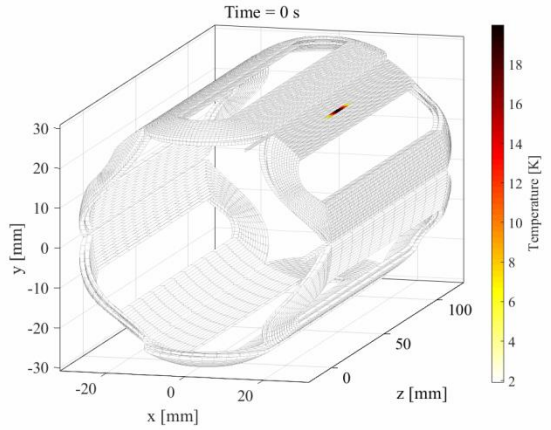
IT BETTER BE A

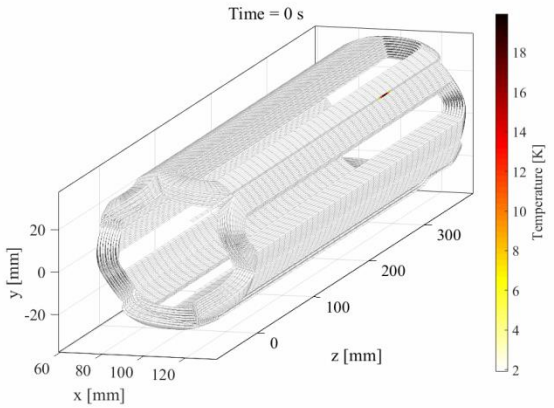
SHORT

COFFEE!



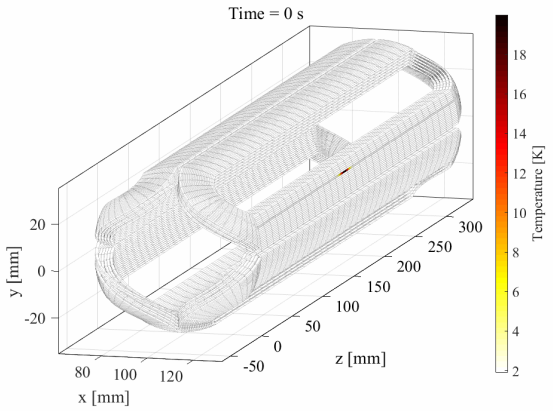


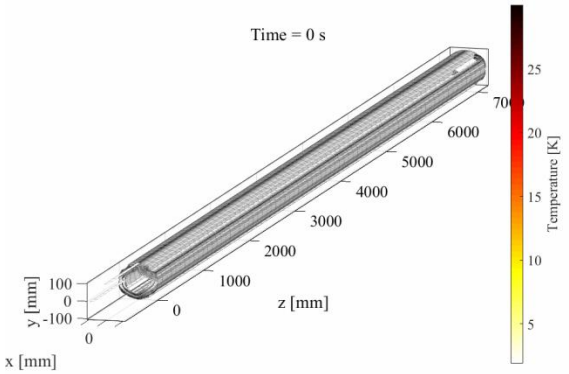




3D SIMULATIONS ARE

~~SLOW~~ *cool*





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https://cern.ch/steam