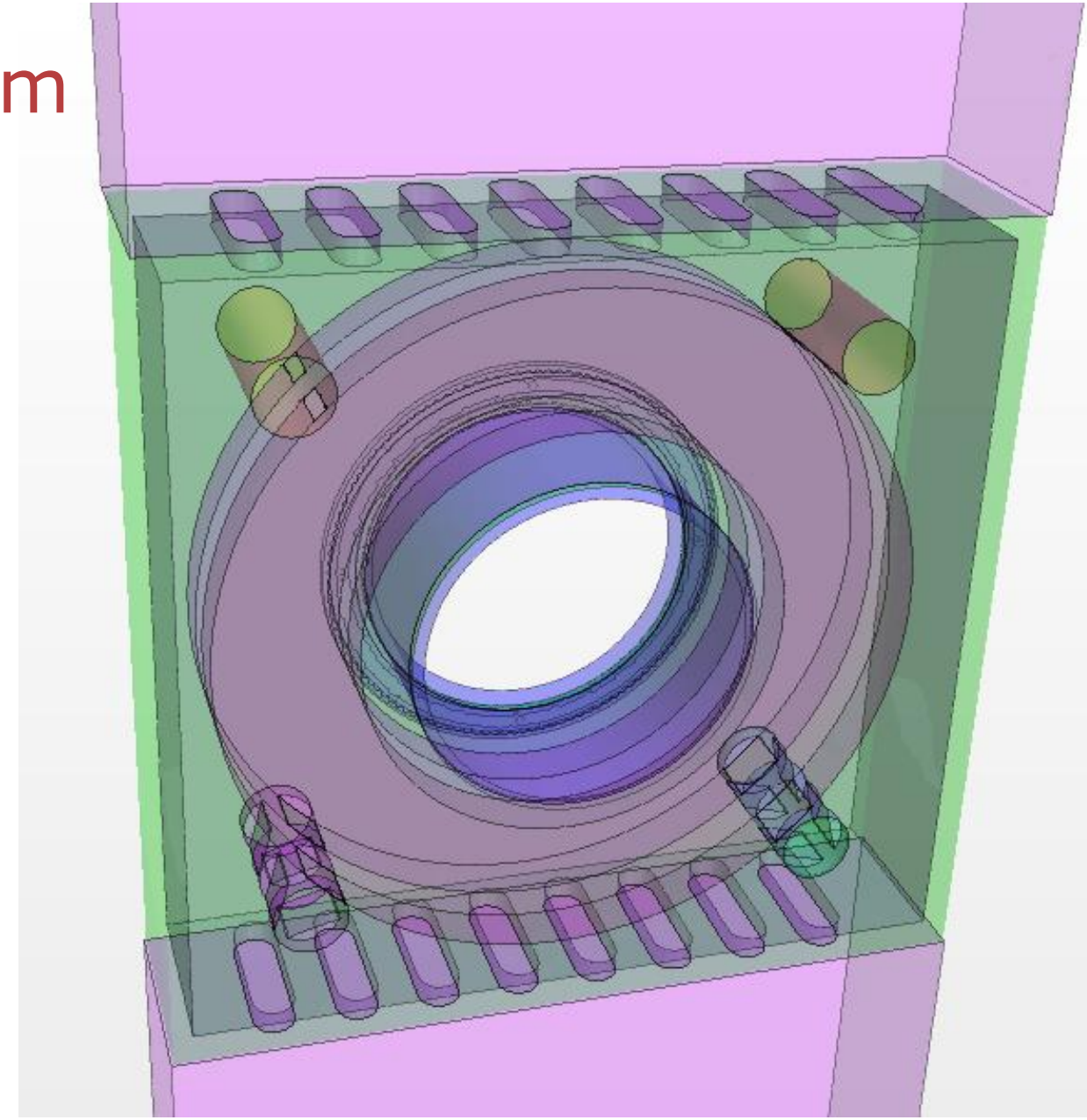
Radio Frequency Cavity Air Cooling

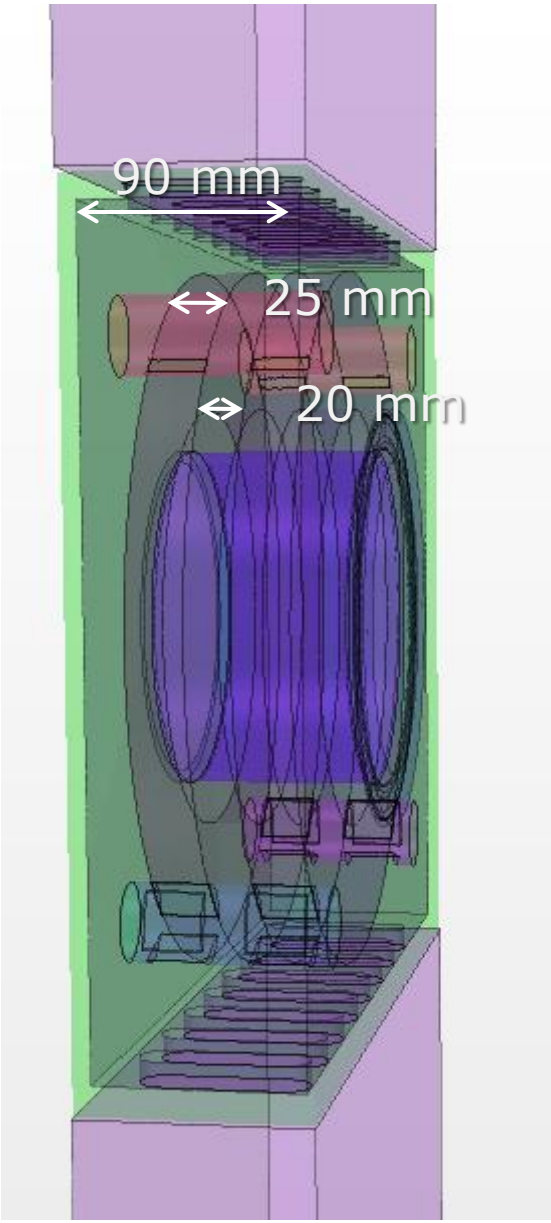
General problem

- New Radio Frequency cavity developed in BE dep.
- 2 coils dissipating 650W each by joule effect.
- Define cooling air mass flow to keep the coils colder than 80 °C.
- Improve cavity shape to reduce hotspots.
- Development time: about 1 month



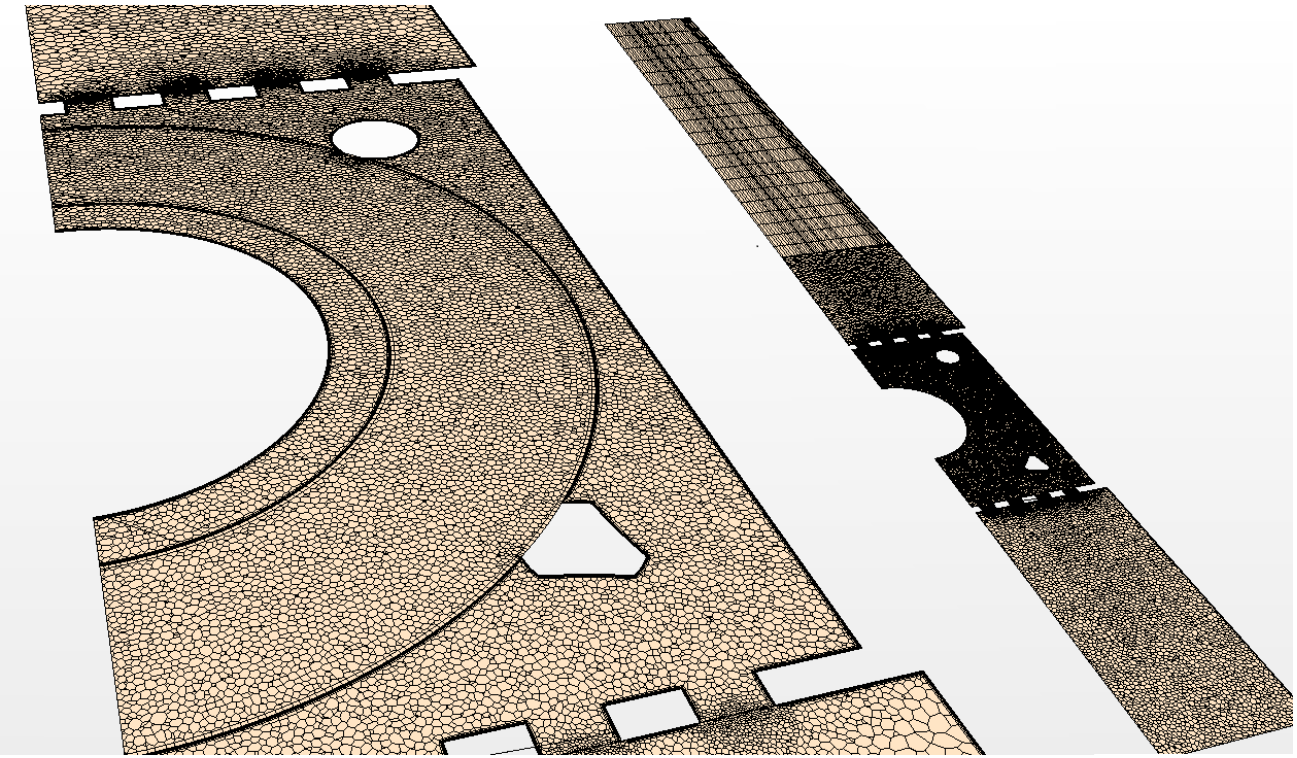
Estimate mass flow in Nominal Conditions

- Thermal conductivity of the rings: 7 W/(m °C)
- Power dissipation per ring : continuous $\approx 1/r^2$ 650 W
- Range of tested air mass flows: 0.1 - 0.5 kg/s



Mesh and numerical models

- Air: compressible ideal gas model
- K-ε Two Layers Turbulence model
- Buoyant flow
- Thermal conduction over the supports and the box are neglected

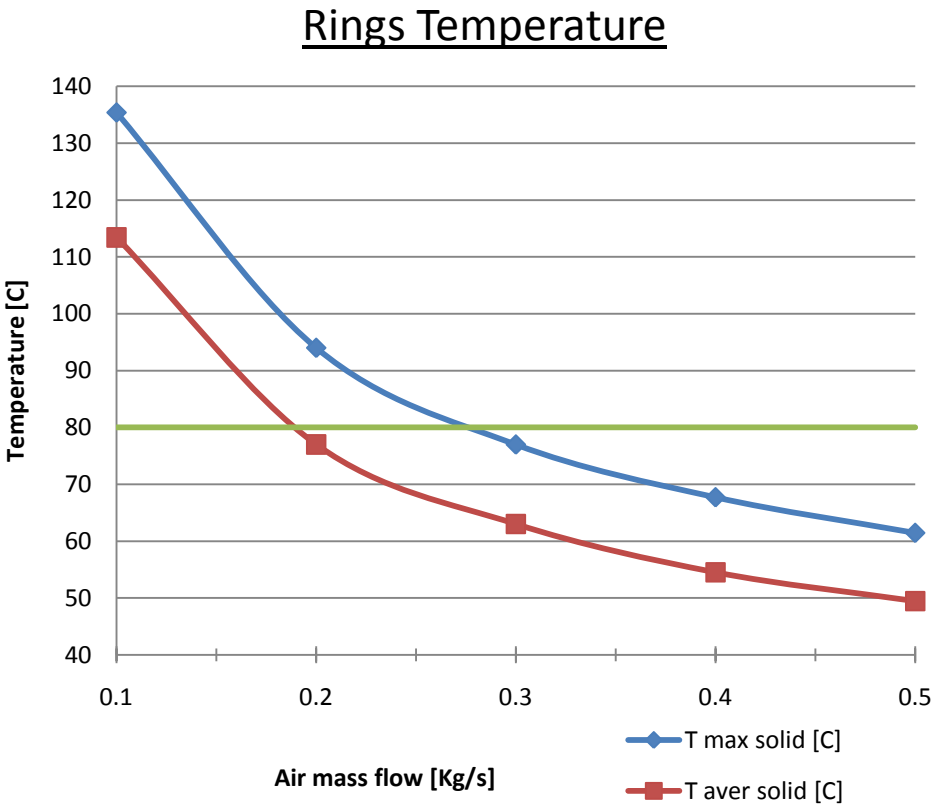


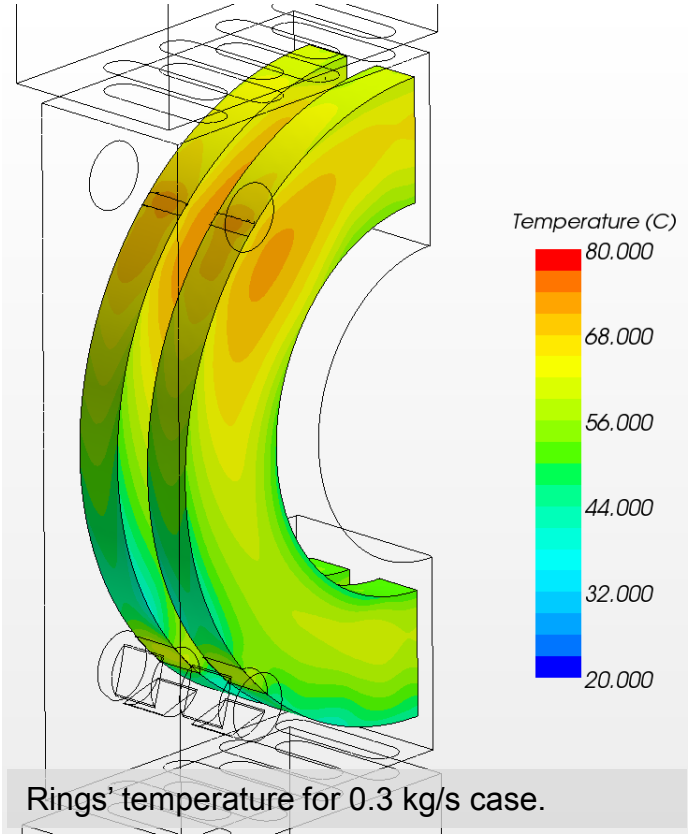
Gas domain
- Core Polyhedral Mesh
- 10 layers cells "boundary layer"
- Extrusion on outlet side

Solid domain
- Core Polyhedral Mesh

Nominal Conditions

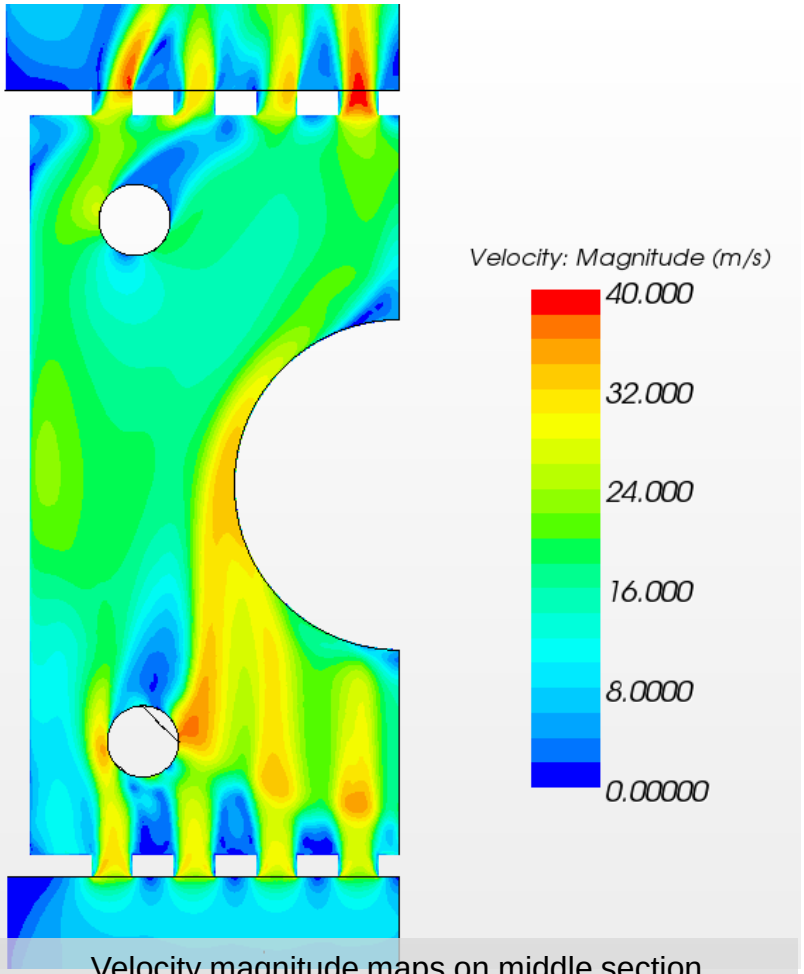
Rings temperature *VS* air mass flow





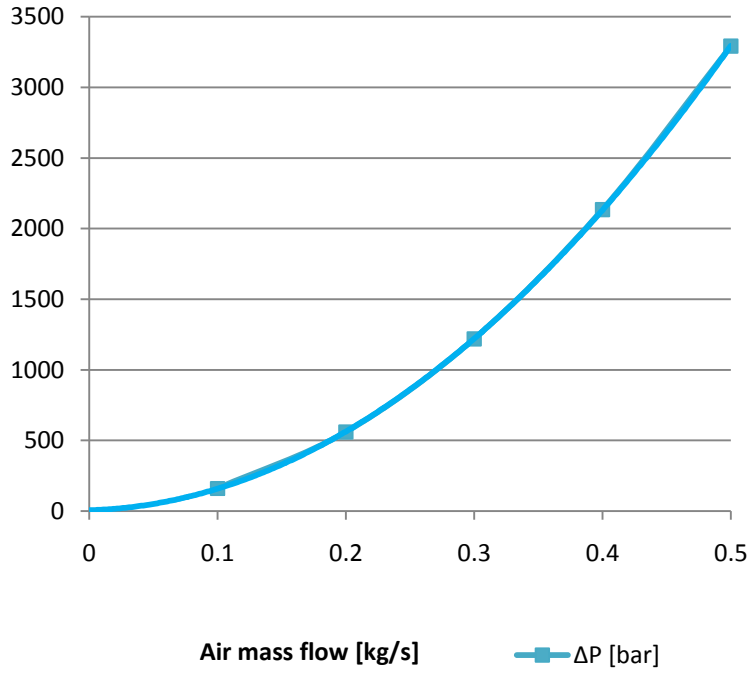
Rings' temperature for 0.3 kg/s case.

Flow at Nominal Conditions



Velocity magnitude maps on middle section
0.3 kg/s case

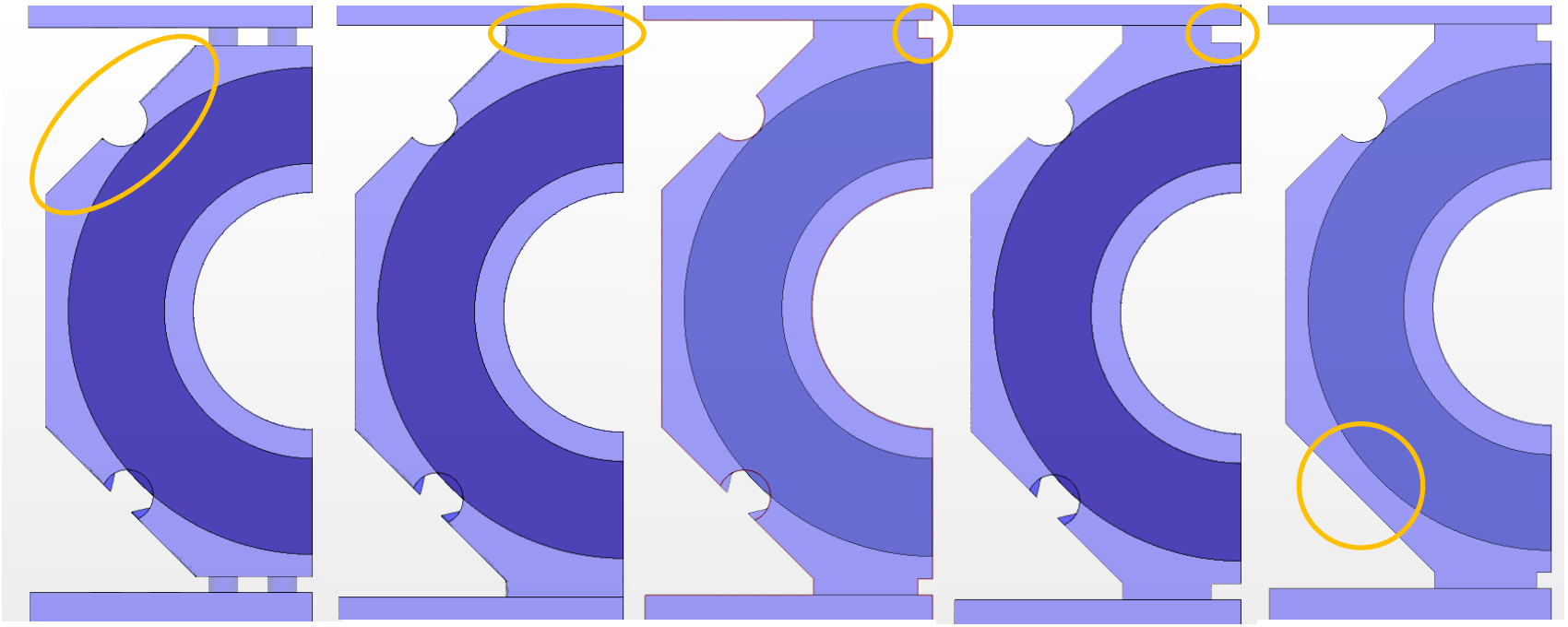
Pressure Drop [Pa]



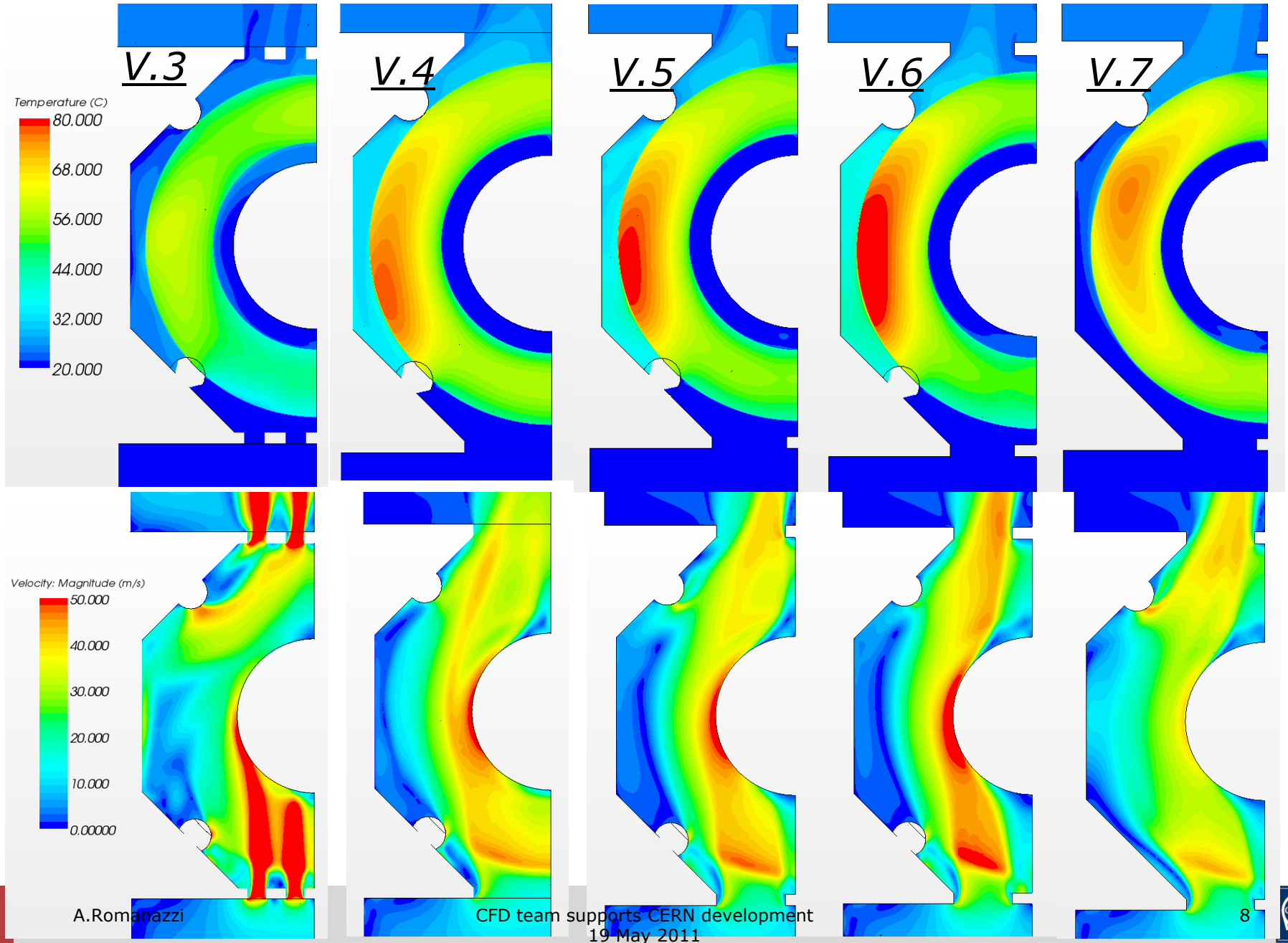
Studied Modified Geometries

Compromise between reducing pressure drop and making the most uniform the Heat transfer coefficient on the coils' surfaces.

V.3 *V.4* *V.5* *V.6* *V.7*

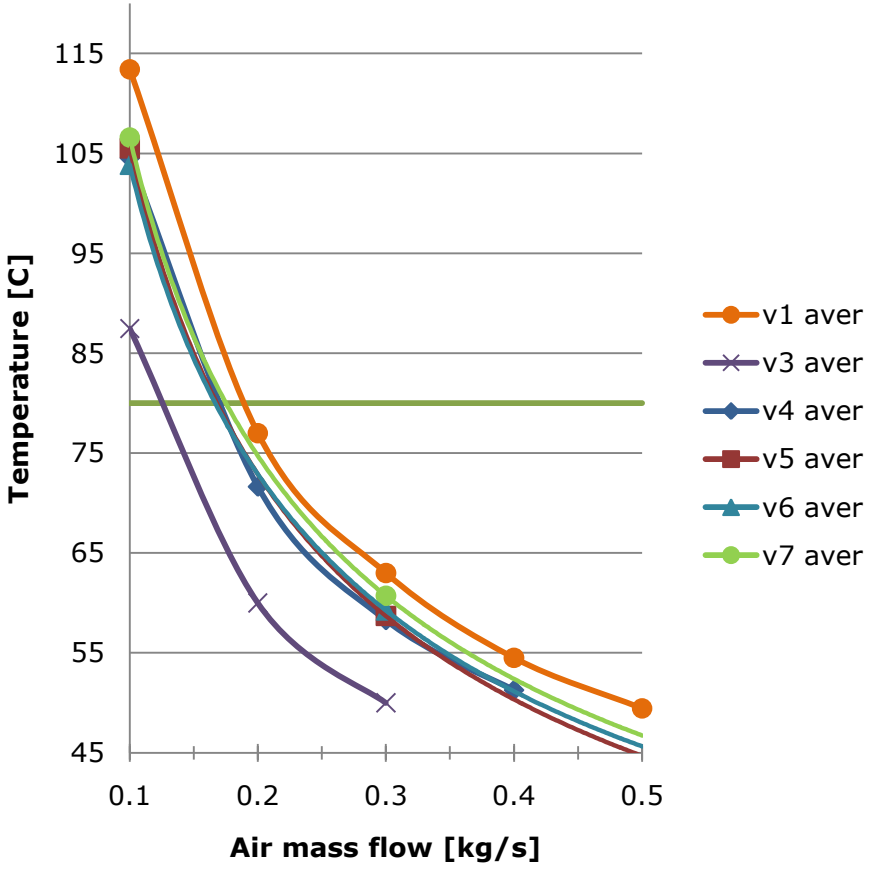


Case: 0.3kg/s

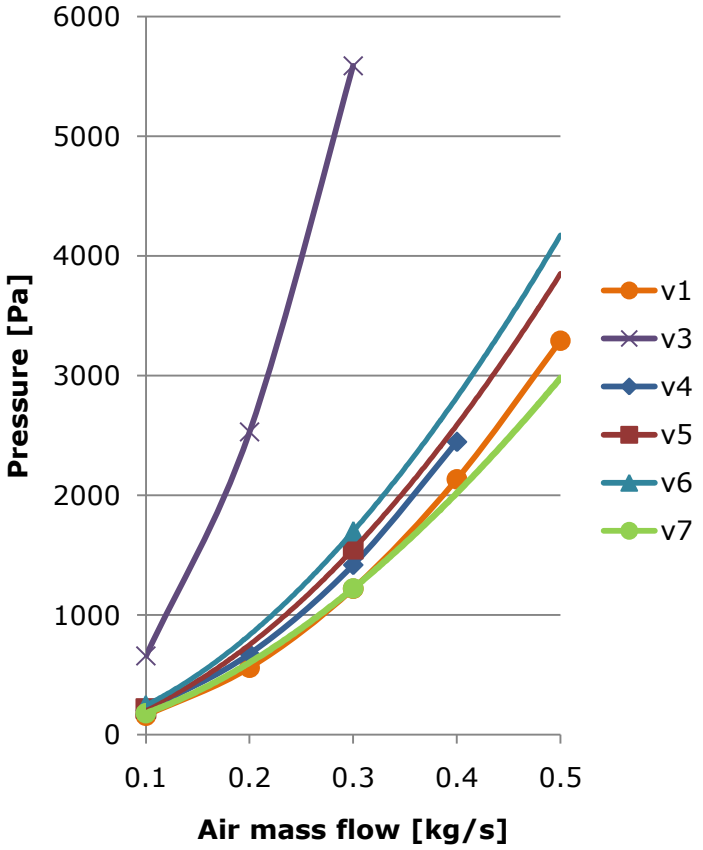

V.3
V.4
V.5
V.6
V.7
Temperature (C)
80.000
68.000
56.000
44.000
32.000
20.000
Velocity: Magnitude (m/s)
50.000
40.000
30.000
20.000
10.000
0.00000

Temperature *VS* Pressure Drop

Rings Max Temperature



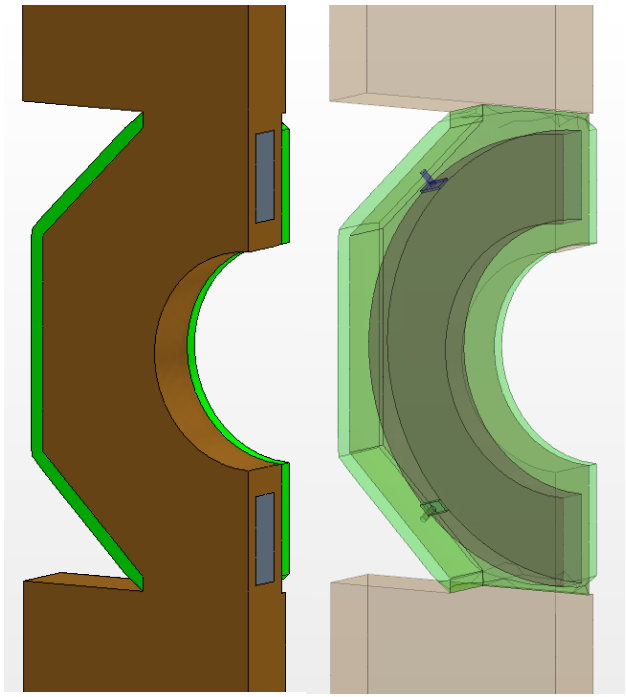
Pressure drop



Final Cavity Layout

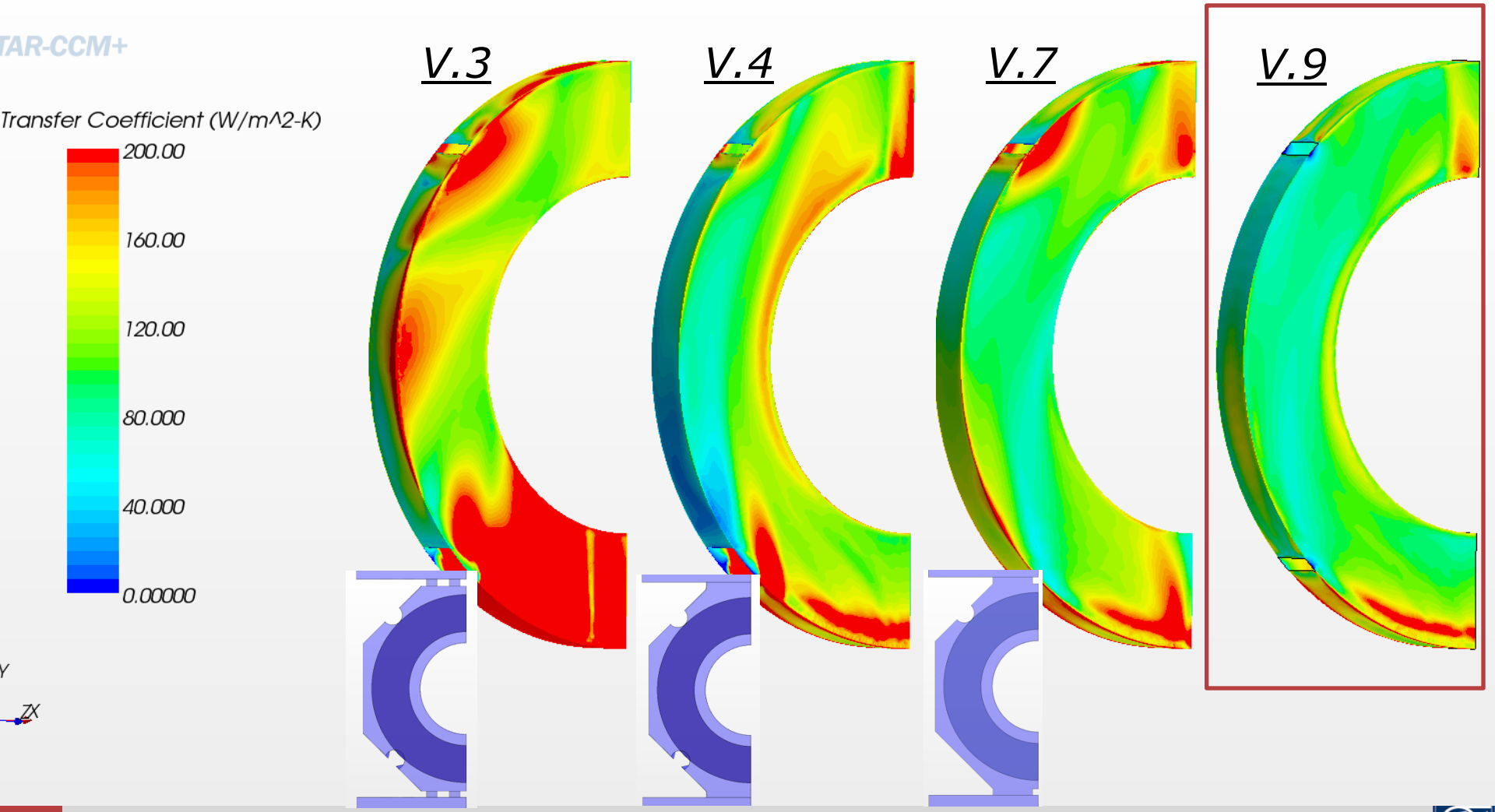
- From treated cases we learn that:
  - Coils' supports interfere with air flow/heat transfer
  - No grills: lower pressure drop
  - Cavity corners have to be "closed"

Version 9

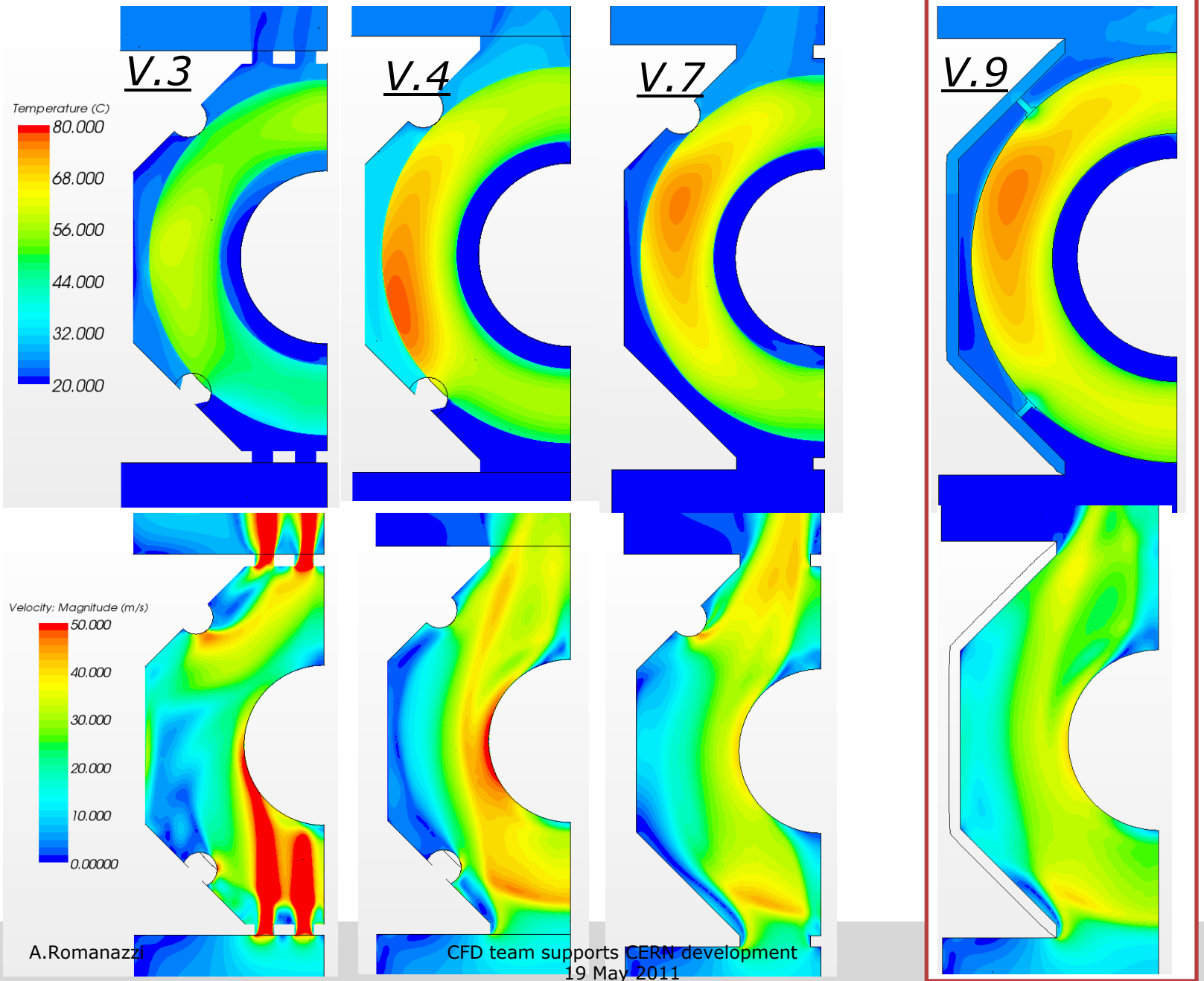


HTC: lower absolute value but more uniform

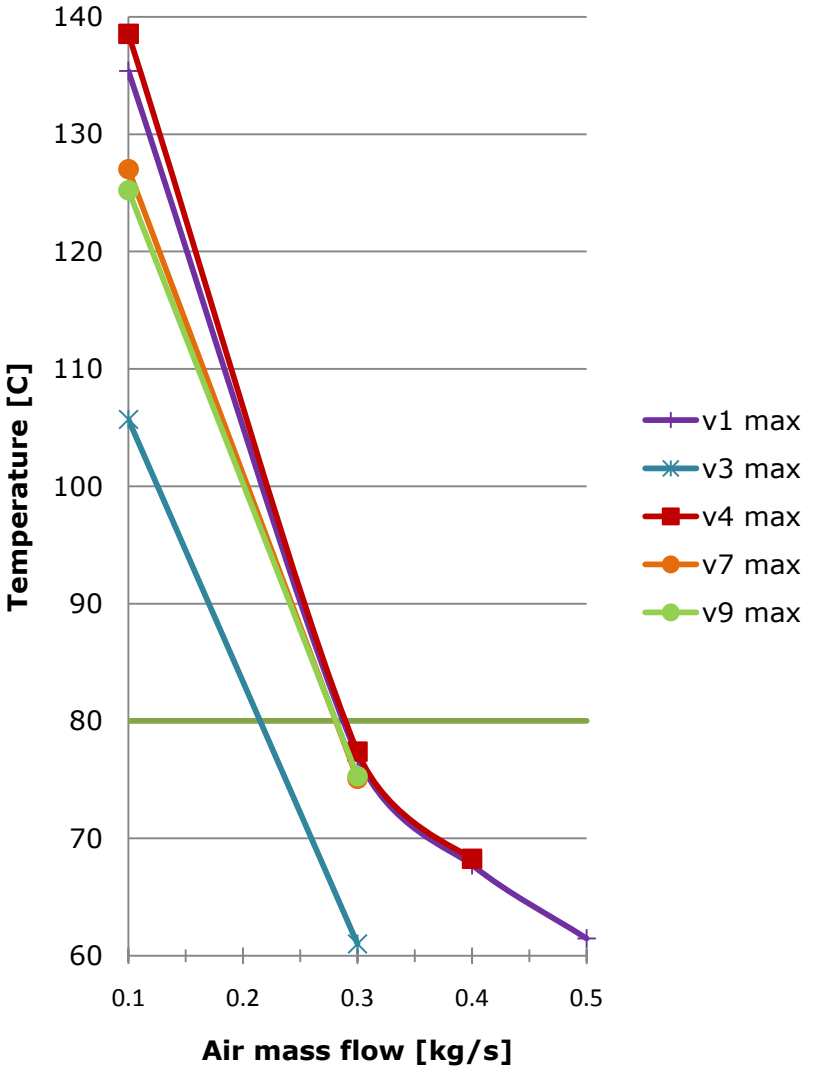
(depends only on air flow pattern – independent from solid properties)



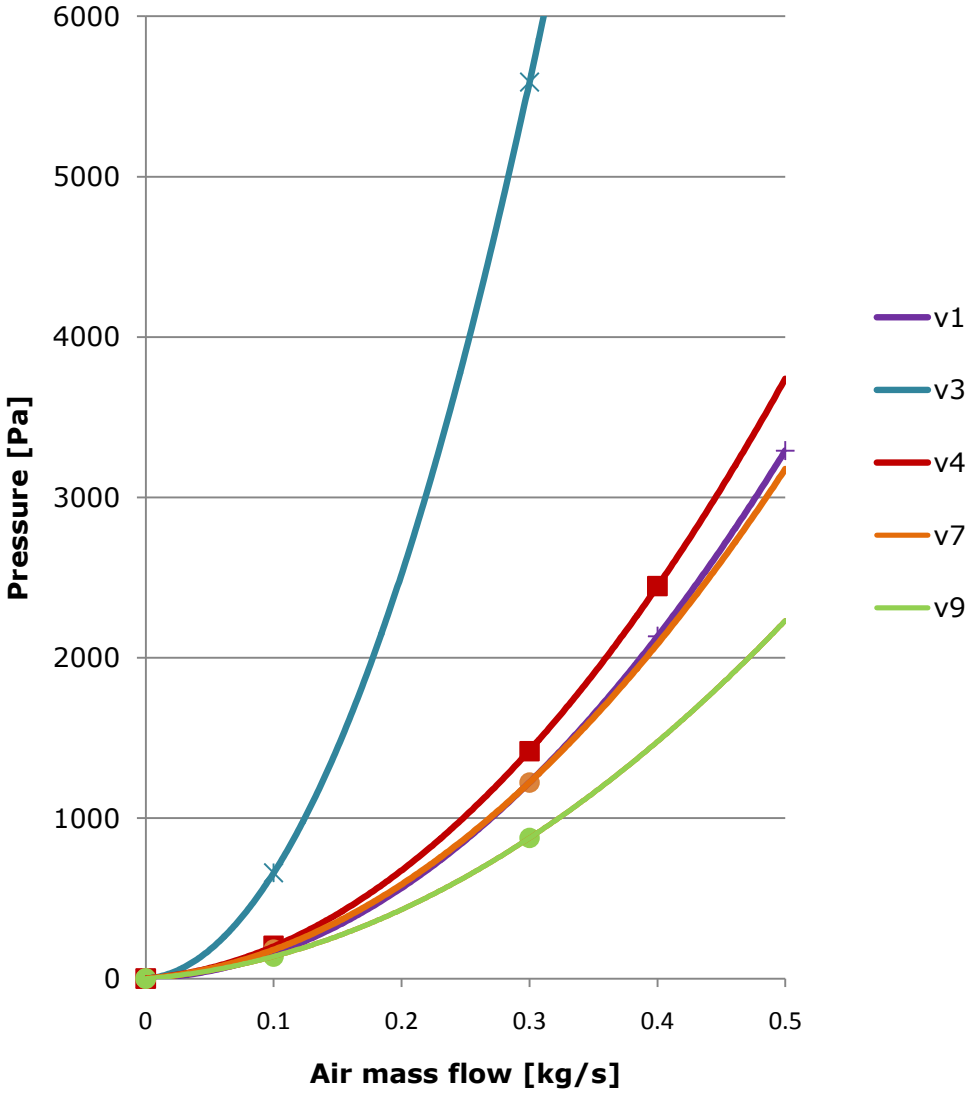
Case: 0.3kg/s


V.3
V.4
V.7
V.9
Temperature (C)
80.000
68.000
56.000
44.000
32.000
20.000
Velocity: Magnitude (m/s)
50.000
40.000
30.000
20.000
10.000
0.00000

Rings Max Temperature



Pressure Drop



Conclusions

Our first target was to estimate a mass flow able to guarantee T<80°C: obtained with a mass flow of 0.3kg/s

Secondly target was to uniform the HTC over the coils' surface to prevent from hot-spots and lower the pressure drop across the system: between the studied geometries "version 9" is the best compromise between those conditions.

Experimental test of the cavity are going to be performed in the next future to validate the cavity and the simulations.

Thank you for your attention!