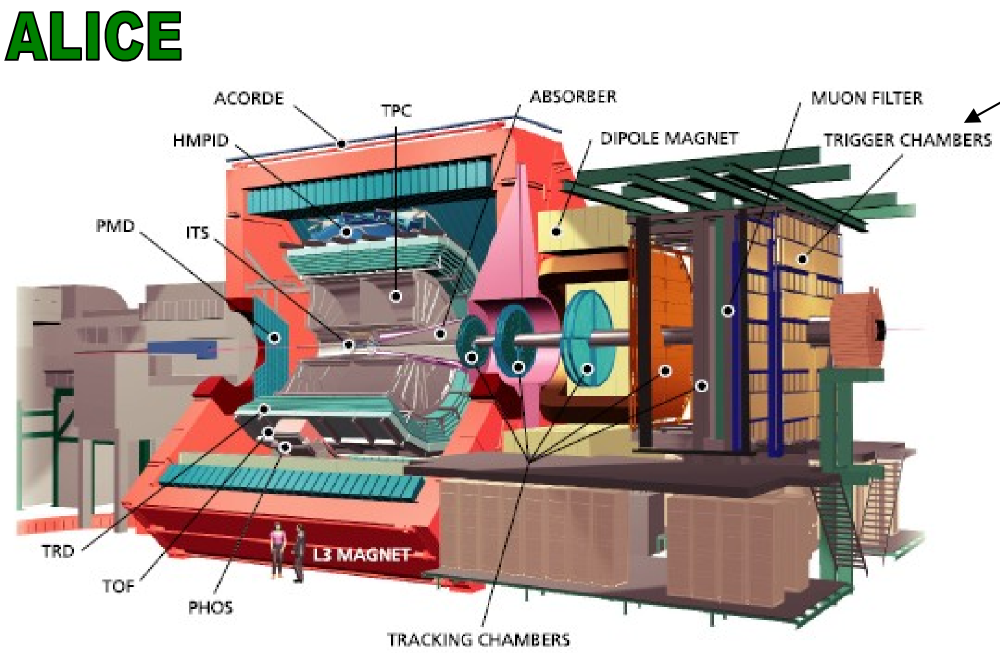
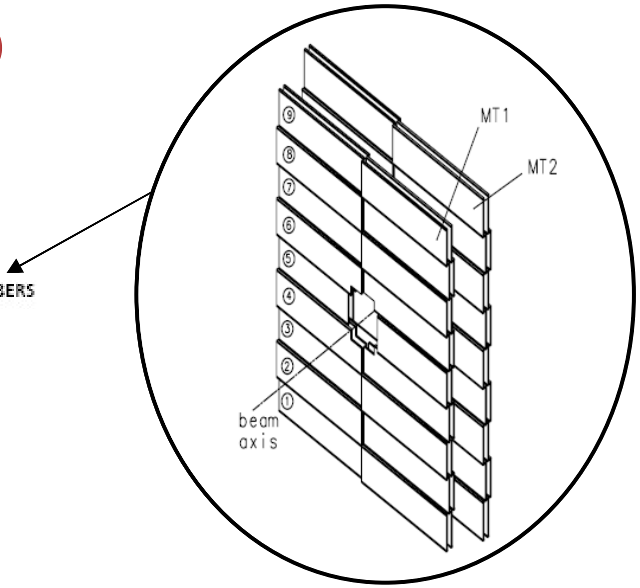
Thermal and Flow Behaviour of the ALICE Muon Trigger Detector

(EDMS 790477/v2)

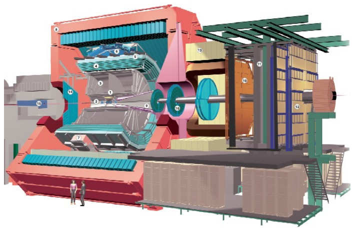




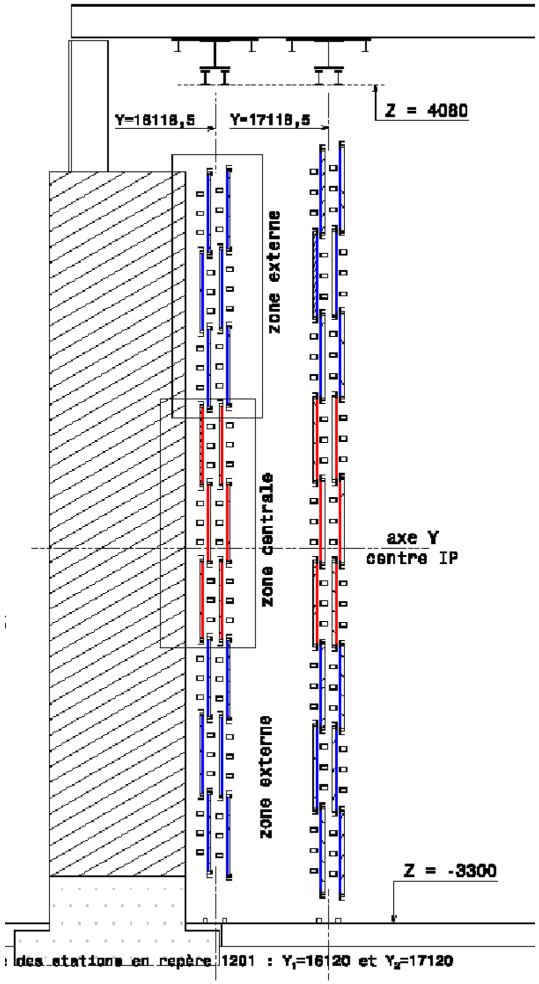
CERN
November 2007

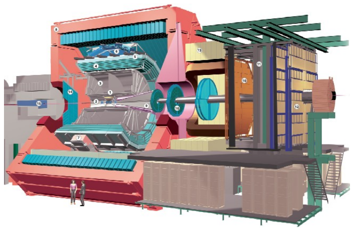
Antonio Romanazzi, Davide Maglio

The Problem



- Two Trigger Stations with electronic equipment dissipating heat to the surroundings;
- As it stands, only natural convection removes the heat generated in the region.
- For operational reasons, temperature in the stations must be within a specified limit.

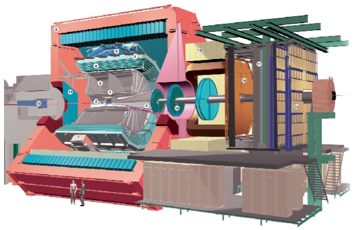




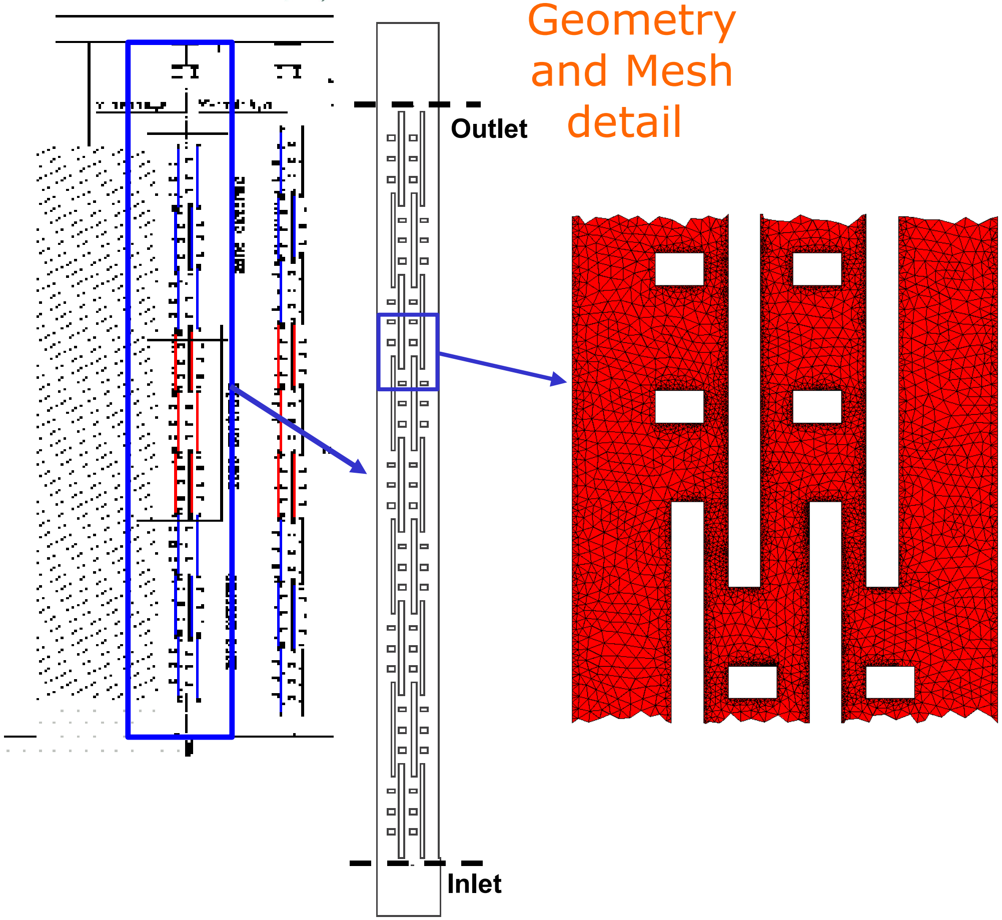
Objectives

1. To study the temperature distribution in the region surrounding the trigger planes

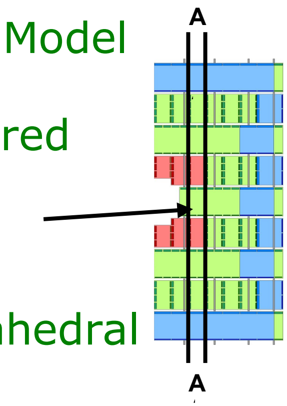
2. To investigate the need to install an additional ventilation system

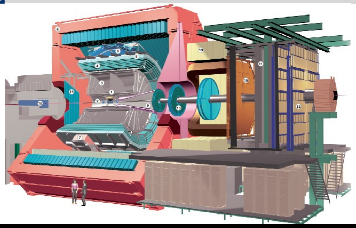


The CFD Model



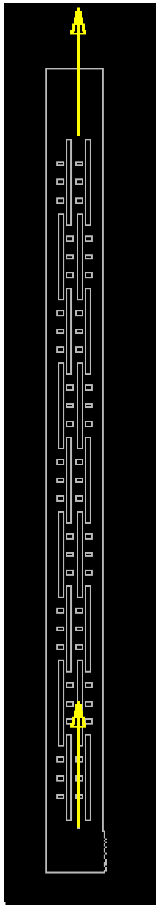
- Steady-state, 2D Model
- Only MT1 considered
- 3rd column slice
- ~125 kcells, tetrahedral
- Heat dissipation from RPC detectors set as constant and uniform heat flux
- Muon iron filter wall set as adiabatic
- Cable storages modelled as void spaces





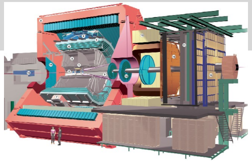
Case studies

Case Name	*Air Flow Conditions*	*General description*
Case 1	Natural Convection	Tambient = 17°C
Case 2		Tambient = 20°C
Case 3	Mixed Convection	Only extraction – Tambient = 20°C; Tvent = 20°C
Case 4		Only extraction – Tambient = 20°C; Tvent = 17°C
Case 5		Only extraction – Tambient = 17°C; Tvent = 17°C
Case 6		Tinlet = 17°C; Tambient = 20°C



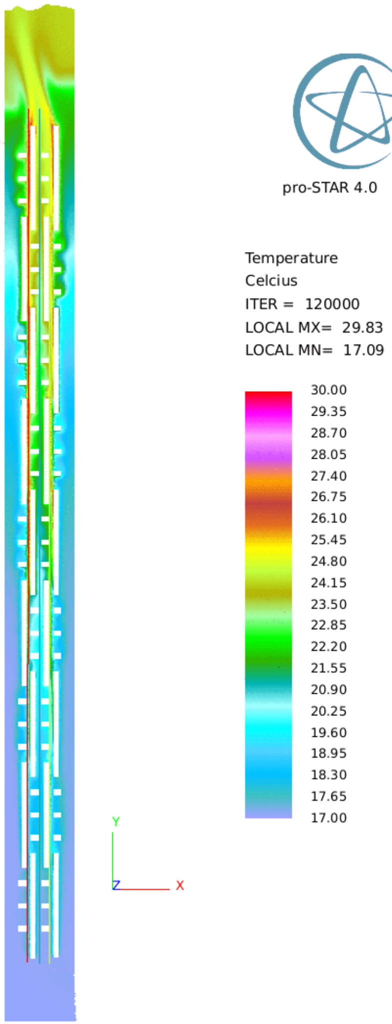
Forced Convection

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Average Temperature, °C	21.0	24.0	23.6	20.4	20.5	20.2
Maximum Temperature, °C	30.0	33.0	33.0	29.8	29.8	29.6
Average Temperature at extraction, °C			25.2	22.2	22.5	22.40
Average Temperature at Outlet, °C	24.0	27.0	24.5	21.5	22.3	20.50
Average Velocity, m/s	0.10	0.11	0.13	0.12	0.12	0.138
Maximum Velocity, m/s	0.44	0.44	1.61	1.60	1.37	3.07
Heat Transfer Coefficient1, W/m^2K	2.3	2.2	2.5	2.4	1.1	5.6
Heat Transfer Coefficient2, W/m^2K	2.8	2.7	3.0	2.9	1.3	11.2
Heat Transfer Coefficient3, W/m^2K	2.9	2.9	3.3	3.2	1.5	28.4
Flow Rate, m^3/h	343	344	182 + 250	184 + 250	188 + 250	265 + 250

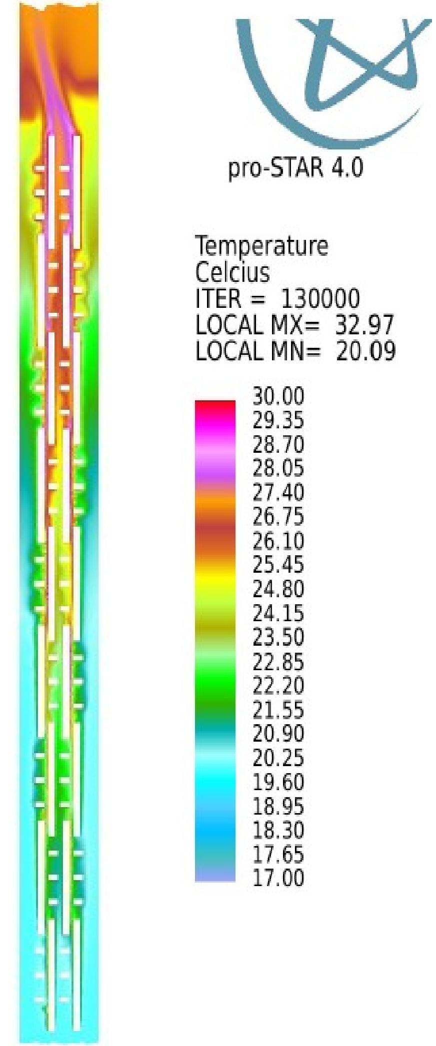


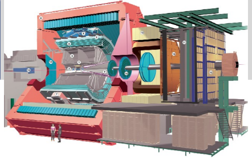
Results

Natural Convection: 17 °C vs 20 °C Ambient Temperature



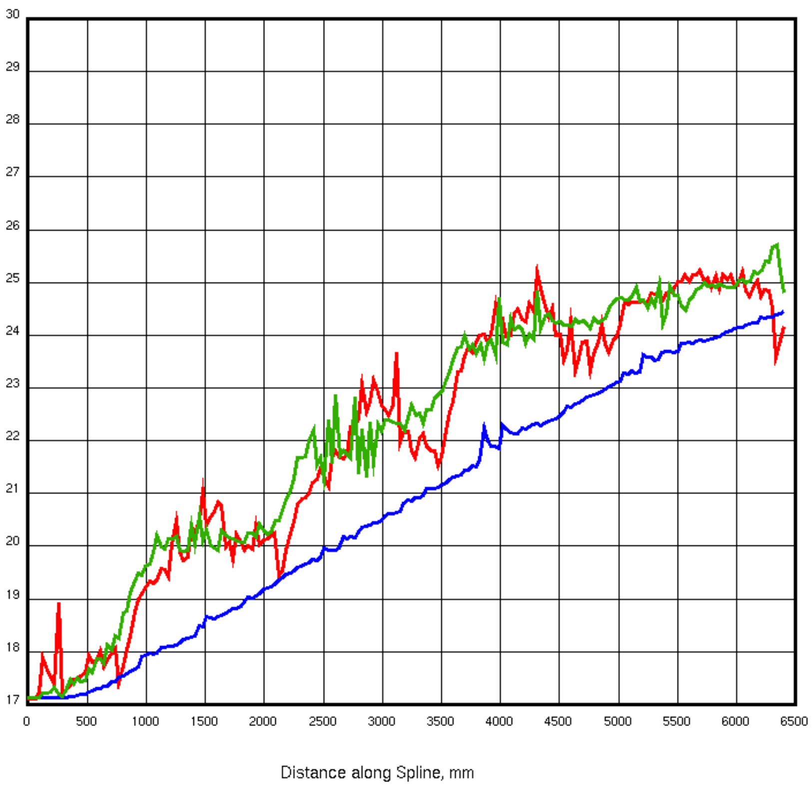
	Case 1	Case 2
Average Temperature, °C	21	24
Maximum Temperature, °C	30	33
Average Temperature at Outlet, °C	24	27
Average Velocity, m/s	0.1	0.1
Maximum Velocity, m/s	0.4	0.4
Heat Transfer Coefficient[1], W/m^2K	2.3	2.2
Heat Transfer Coefficient[2], W/m^2K	2.8	2.7
Heat Transfer Coefficient[3], W/m^2K	2.9	2.9
Flow Rate, m^3/h	343	344

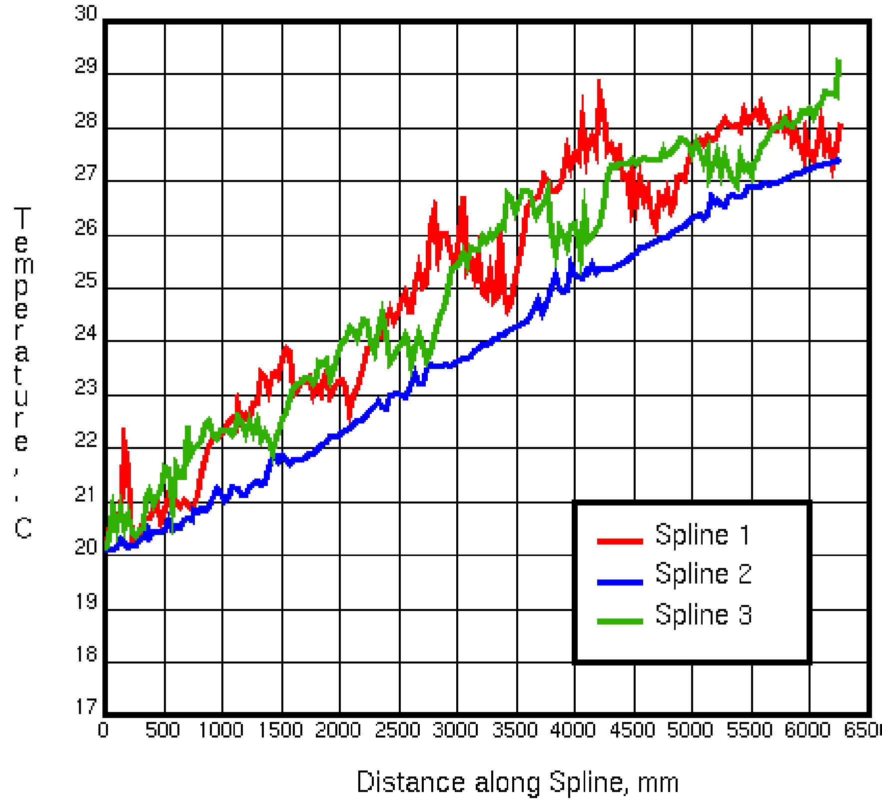


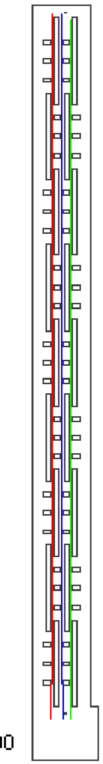


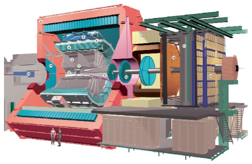
Results

Natural Convection: 17 °C vs 20 °C Ambient Temperature



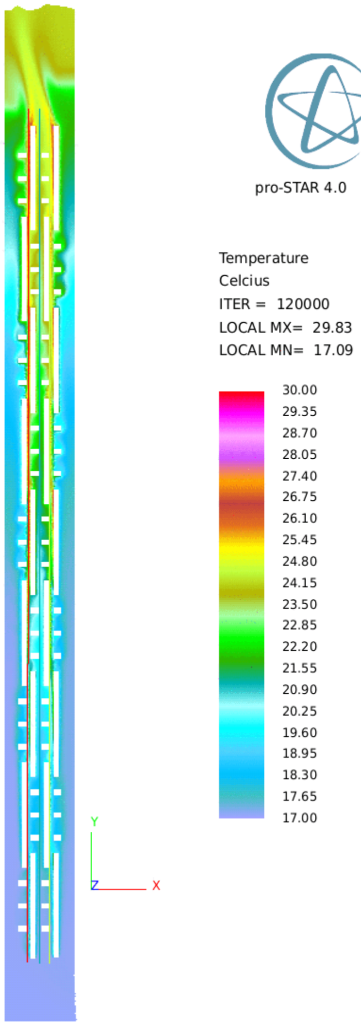




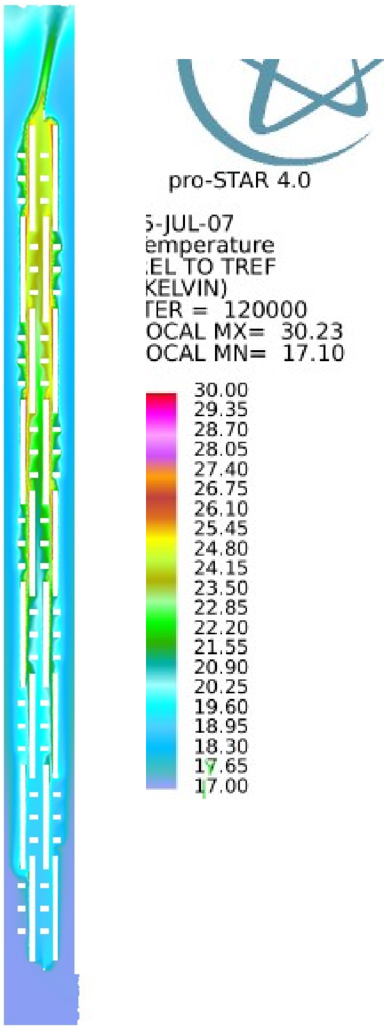


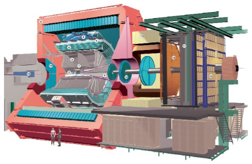
Results

Natural vs Forced Convection at 17 °C



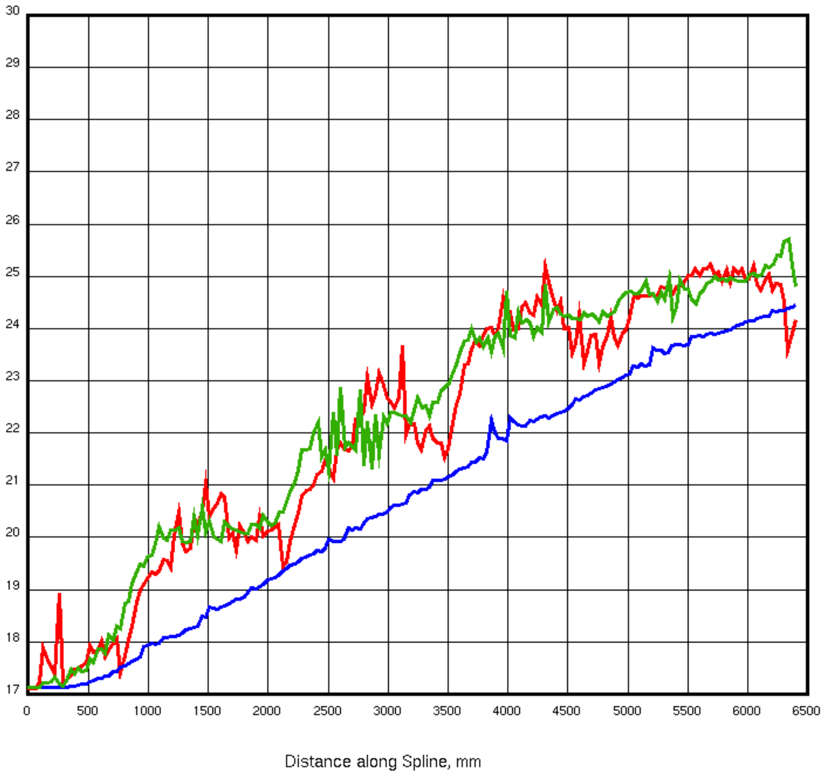
	Case 1	Case 6
Average Temperature, °C	21	20
Maximum Temperature, °C	30	30
Average Temperature at Outlet, °C	24	22
Average Temperature at Extraction, °C		21
Average Velocity, m/s	0.1	0.1
Maximum Velocity, m/s	0.4	3.0
Heat Transfer Coefficient[1], W/m^2K	2.3	5.6
Heat Transfer Coefficient[2], W/m^2K	2.8	11.2
Heat Transfer Coefficient[3], W/m^2K	2.9	28.4
Flow Rate, m^3/h	343	265 + 250

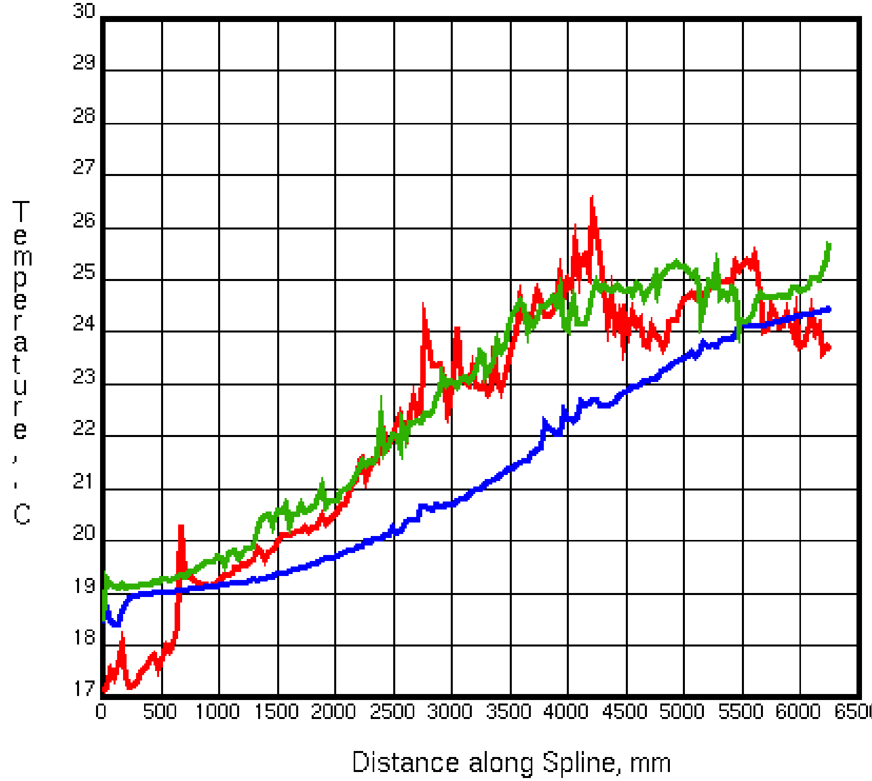


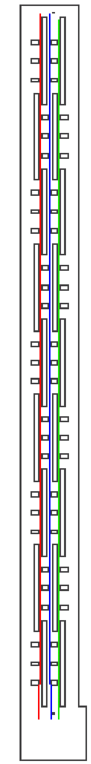


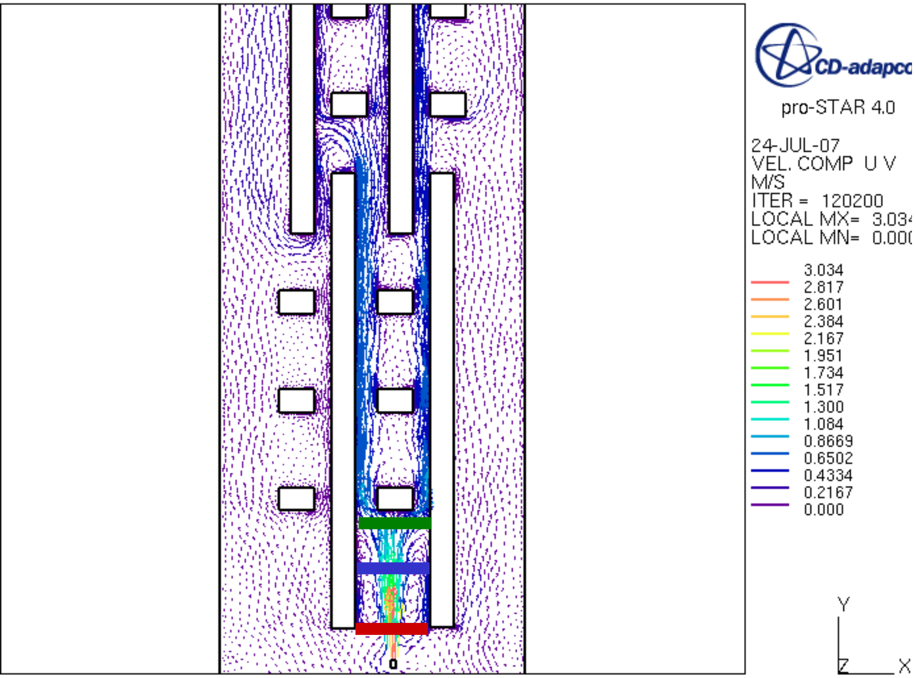
Results

Natural vs Forced Convection at 17 °C








CD-adapco
pro-STAR 4.0
24-JUL-07
VEL. COMP U V
M/S
ITER = 120200
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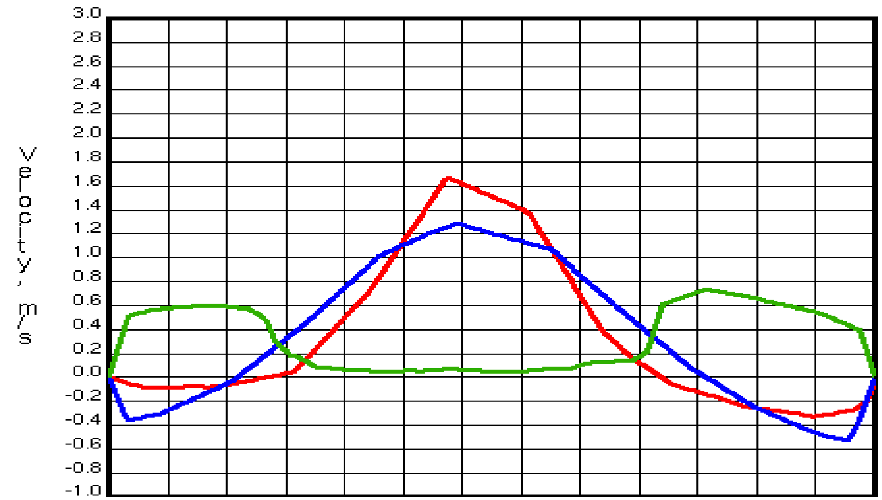
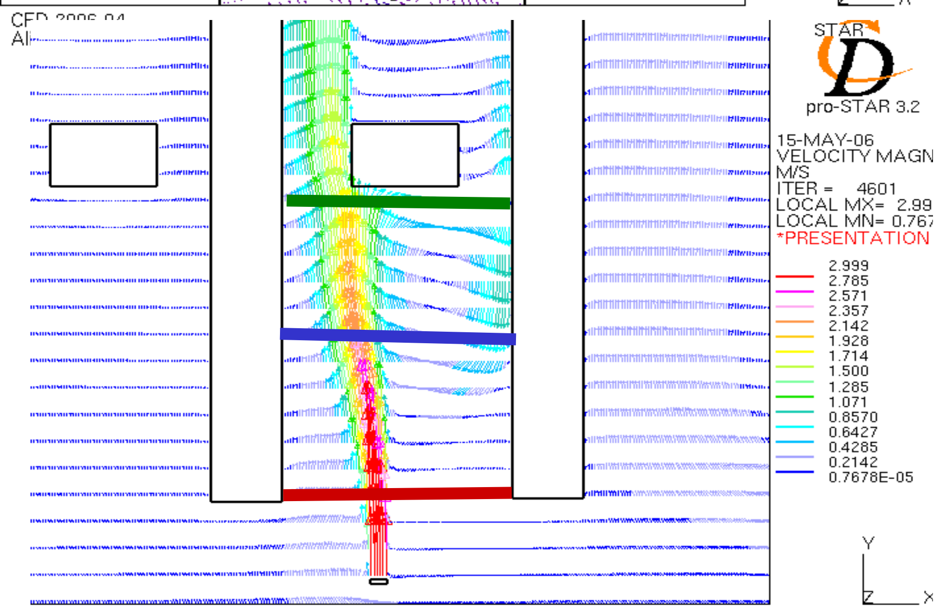
2.817
2.601
2.384
2.167
1.951
1.734
1.517
1.300
1.084
0.8669
0.6502
0.4334
0.2167
0.000
Y
Z
X


Velocity, m/s
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0


STAR
pro-STAR 3.2
15-MAY-06
VELOCITY MAGN
M/S
ITER = 4601
*PRESENTATION
2.999
2.785
2.571
2.357
2.142
1.928
1.714
1.500
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1.071
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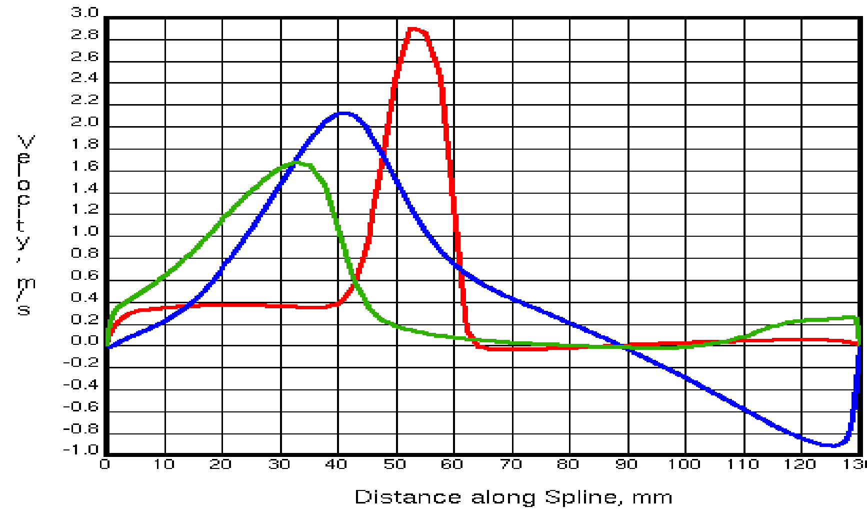
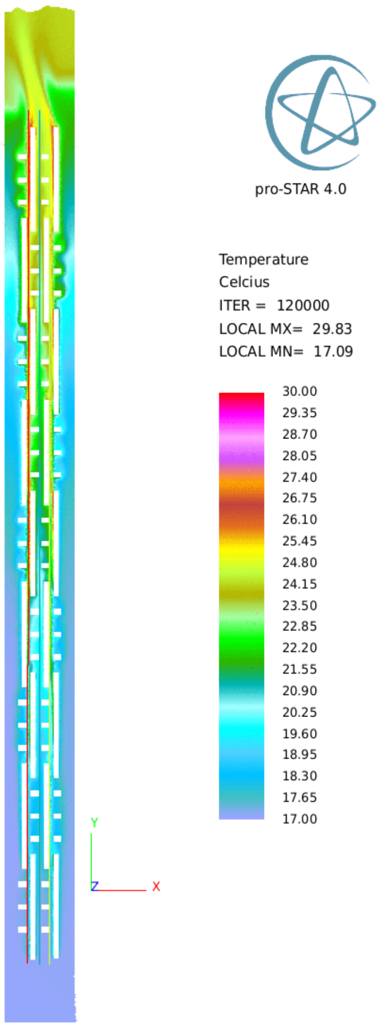
0.2142
0.7676E-05
Y
Z
X

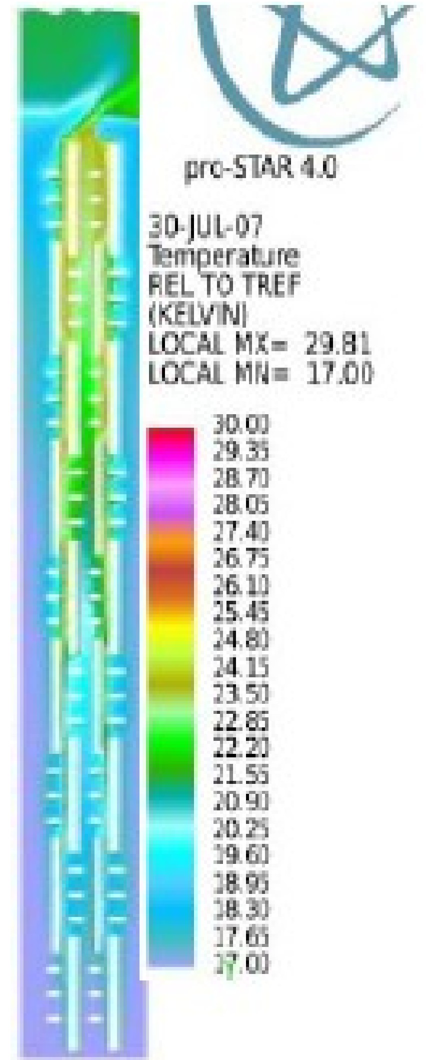

Velocity, m/s
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Distance along Spline, mm

Results

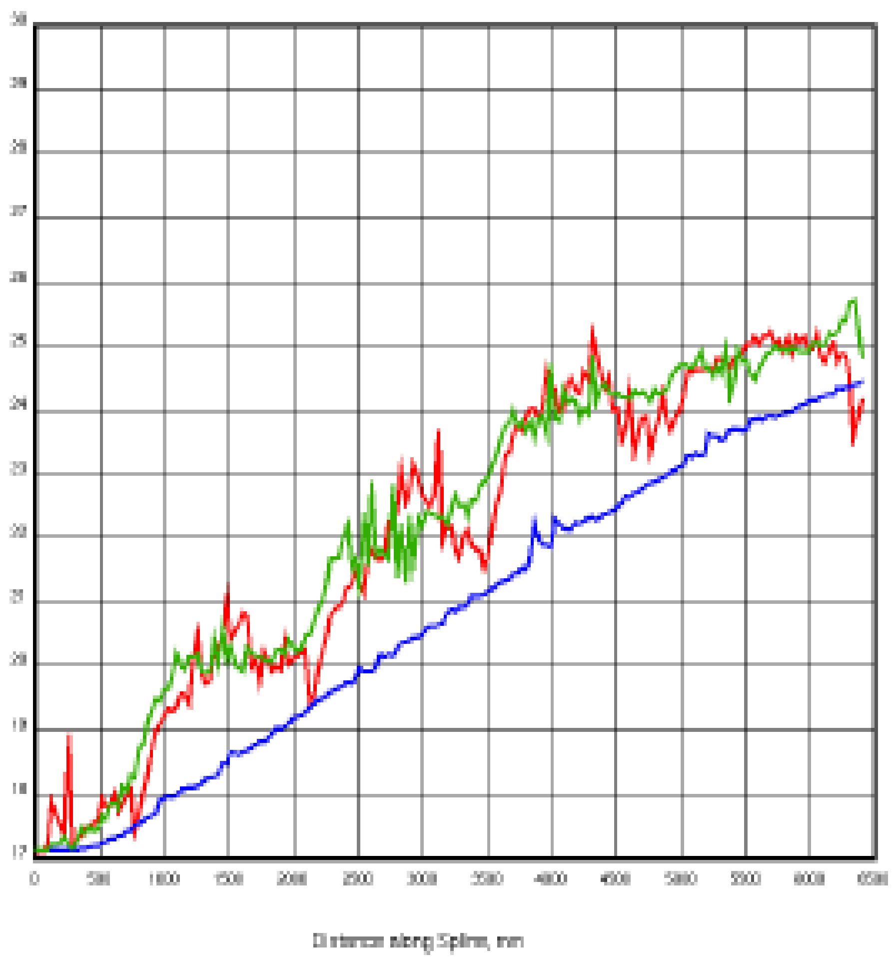
Natural Convection at 17 °C – with or without extraction

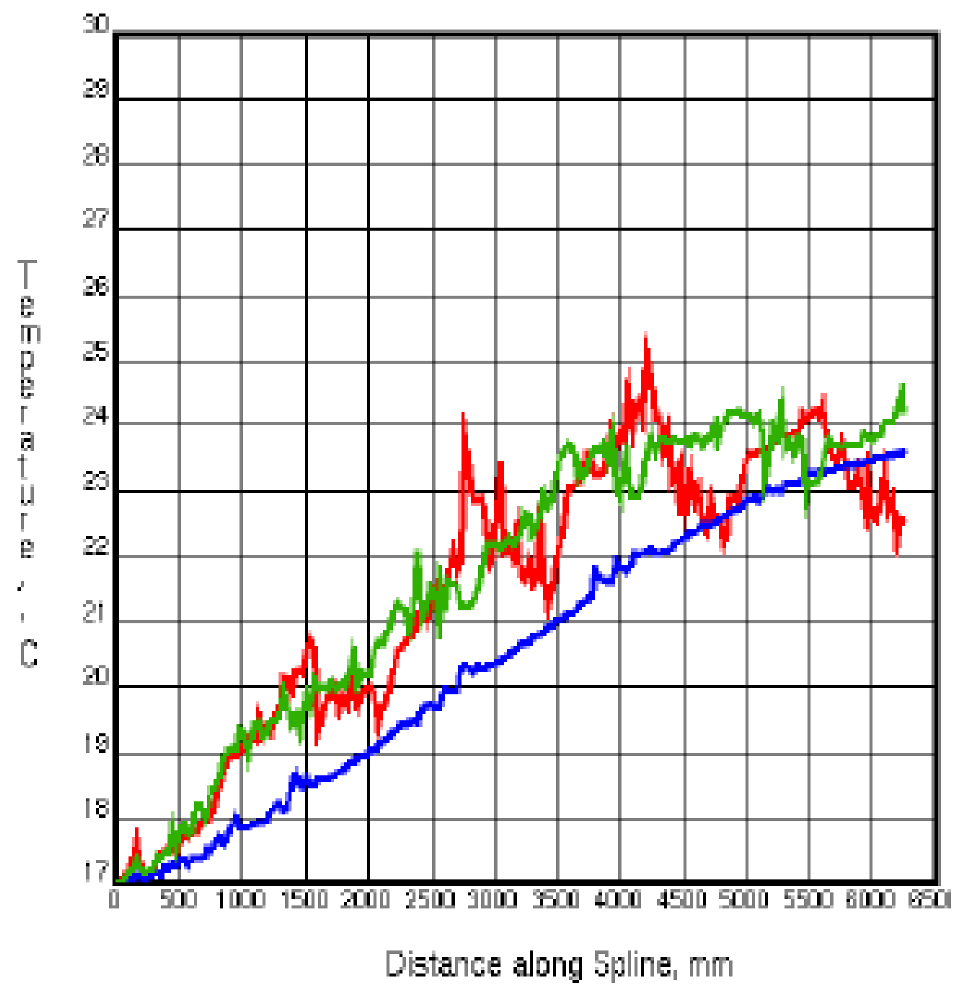


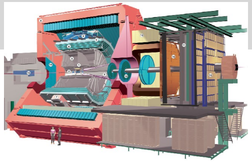
	Case 1 - No extraction	Case 4 - With extraction
Average Temperature, °C	21.0	20.4
Maximum Temperature, °C	30.0	29.8
Average Temperature at Outlet, °C	24.0	22.2
Average Temperature at extraction, °C		21.5
Average Velocity, m/s	0.10	0.12
Maximum Velocity, m/s	0.44	1.60
Heat Transfer Coefficient[1], W/m^2K	2.3	2.4
Heat Transfer Coefficient[2], W/m^2K	2.8	2.9
Heat Transfer Coefficient[3], W/m^2K	2.9	3.2
Flow Rate, m^3/h	343	184 + 250



Results
Natural Convection at 17 °C – With or without extraction







Conclusions

In the case of natural convection maximum temperature keeps lower then 30 °C and 33 °C (17 °C and 20 °C respectively)

Augmentation of ambient temperature scales the temperature field of the same factor without relevant modifications on the general behavior

Forced ventilation produce a decrease of temperature only on the lower RPCs

An exhausting system just above trigger planes does not provide relevant benefits in terms of temperatures