Design of the cooling system for the Readout Module Box of the Hadron Calorimeter Detector.

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Cooling Upgrade system RBx

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Agenda

- Cooling status
- Previous work
- Findings and Discussion
- Conclusions and Implications
- Future work

COOLING STATUS

Overview

CMS → HCAL → HB → RBx

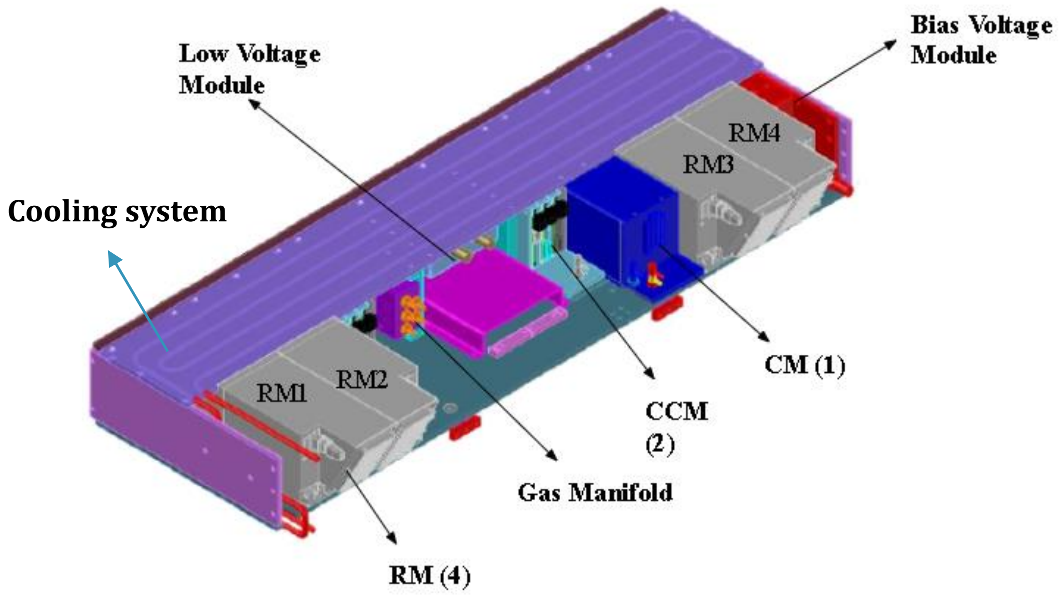


Fig. 1.: Readout Box

Problem

- Insufficient heat dissipation (cooper system)
- High temperatures reduces:
  - Lifetime of the QIE Cards

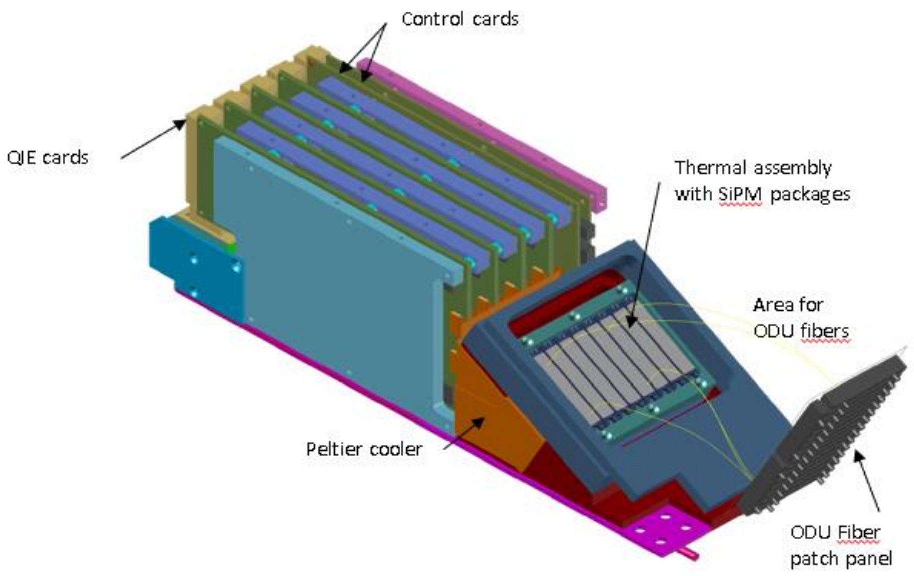


Fig. 2.: RM & QIE cards

PREVIOUS WORK

Objectives

- Reduce QIE cards temperature
- Selection of a proposal
- Design a feasible design

Close up

- Literature review and theory
- Analysis (Temperature/Length)
- Simulation (Proposal performance)

Cooling system(floor)

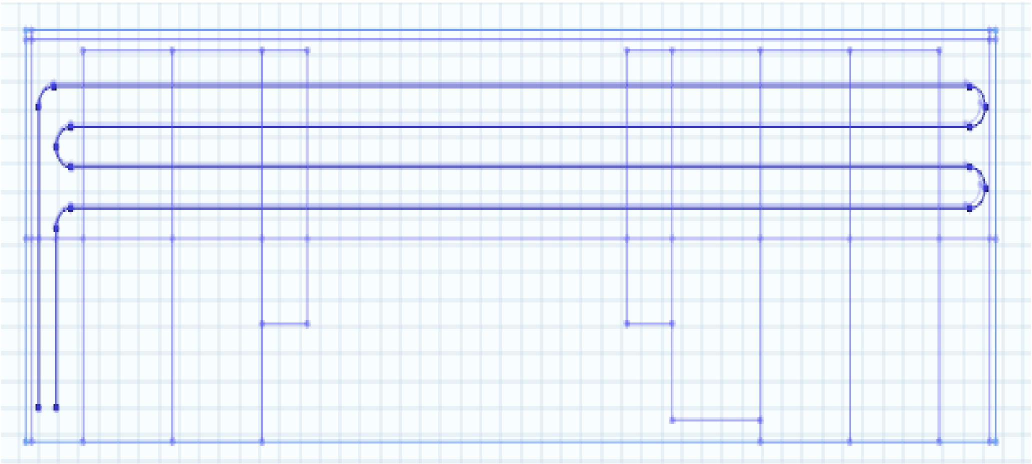


Fig. 3.: Present design

Literature review and theory

- Thermodynamics , Heat Transfer & Fluid flow theory
- Comsol Multiphysics software information
- Parameters/ Variables > Cads

METHODOLOGY

Review parameters & variables

Parameters :

- Geometry

Modules & RBx exterior measurements

Table 1: General known parameters

Variable	Value (unit)
Outside Diameter of the tubes (OD)	3/16 (in)
Internal Diameter of the tubes (ID)	1/8 (in)
Water Flow rate (Q)	1 (lpm)
Water Inlet temperature	20 (°C)
Tube length (L)	4.138 (m)

- Assumption of heat load losses

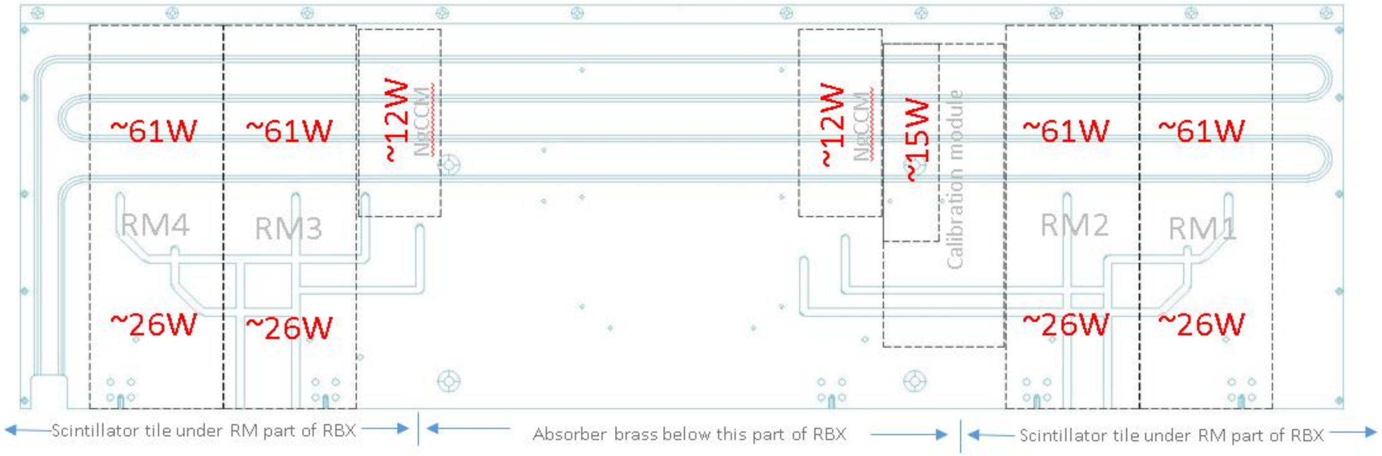


Fig. 4 : Floor heat load losses

- Materials

➤ Aluminium 6061 (Modules & RBx)
➤ Copper (tubes)
➤ Water (Coolant liquid)

Variables:

- Tube length
- Loop distribution

ANALYSIS

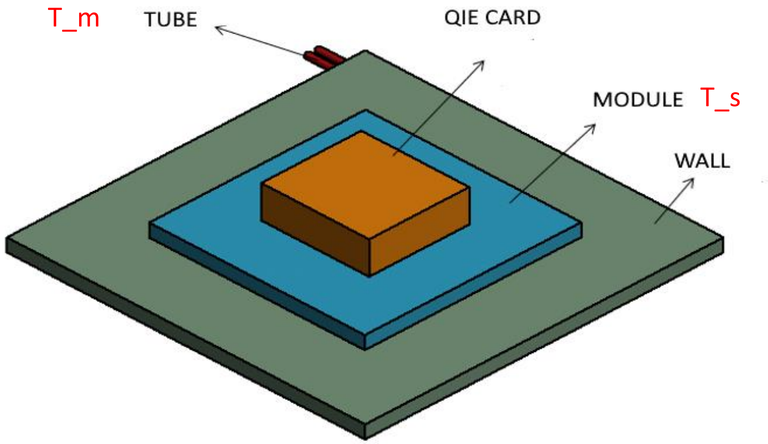


Fig. 5 : Analysis model simplification

Table 2: Assumptions

One dimensional analysis	Copper resistance is negligible
Steady state system	No fouling consider
Fully developed flow	No corrosion consider
Incompressible fluid without phase changes	Copper resistance is negligible
No conduction in the fluid, just convection	No radiation consider
Isotropic materials	No contact resistances consider
Bousiness approximation taken for the fluid[5]	

Objective

- Determine how the length of the coppper tube effect over the temperature of the module and the water.
- Use the thermal resistance analogy for heat transfer analysis.
- Determine the fluid properties (Re, Nu, h)

SIMULATION

Close up

- Simulation model
- Proposal designs
- Simulation run

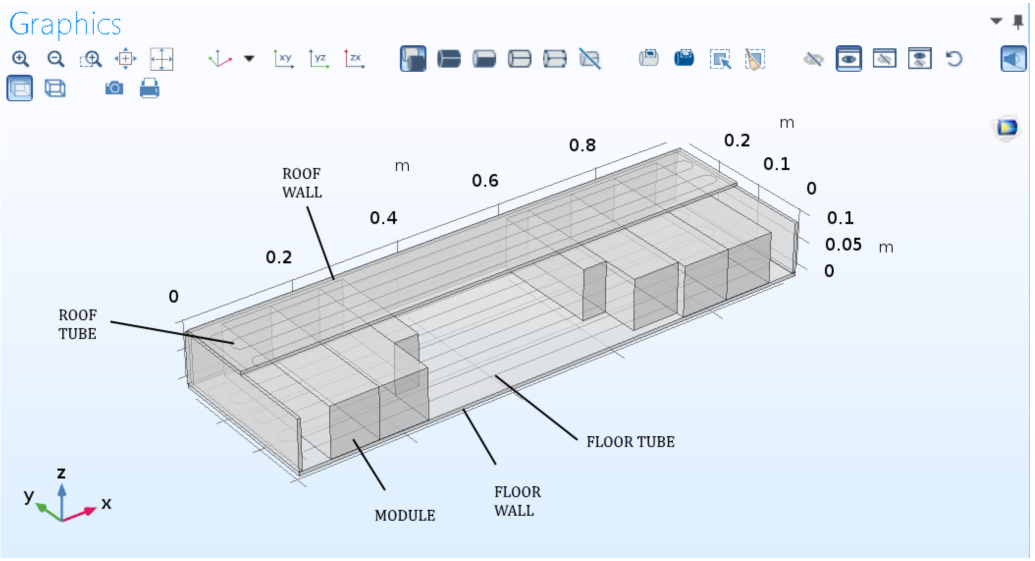
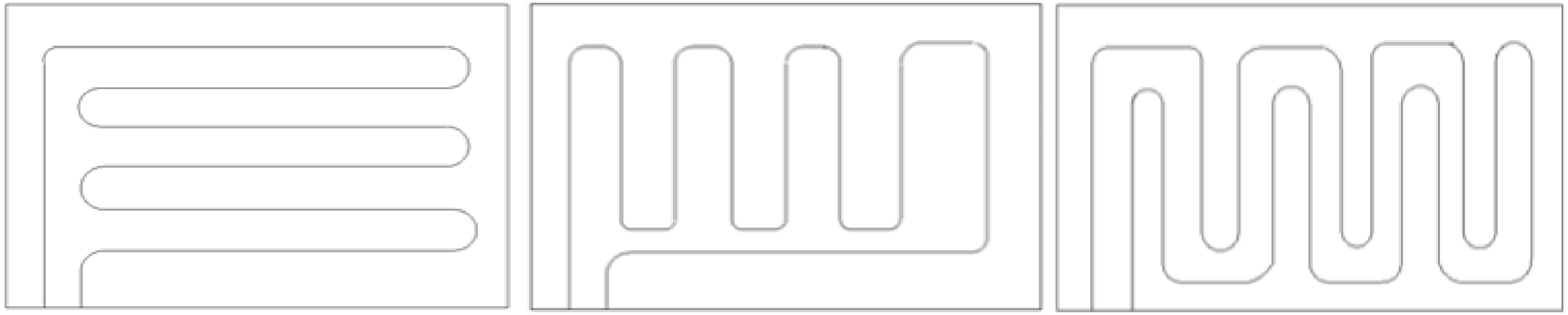


Fig.6.: Simplified Comsol model of the system

- Cooper bend specifications
- Similar applications
- Loop programmation

Fig.7.: Proposal designs



a) b) c)

Objective

- Determine how the loop configuration affect the heat transfer
- Compare the design proposals
- Select the best heat transfer cooling system

FINDINGS AND DISCUSSIONS

SIMULATION RUN

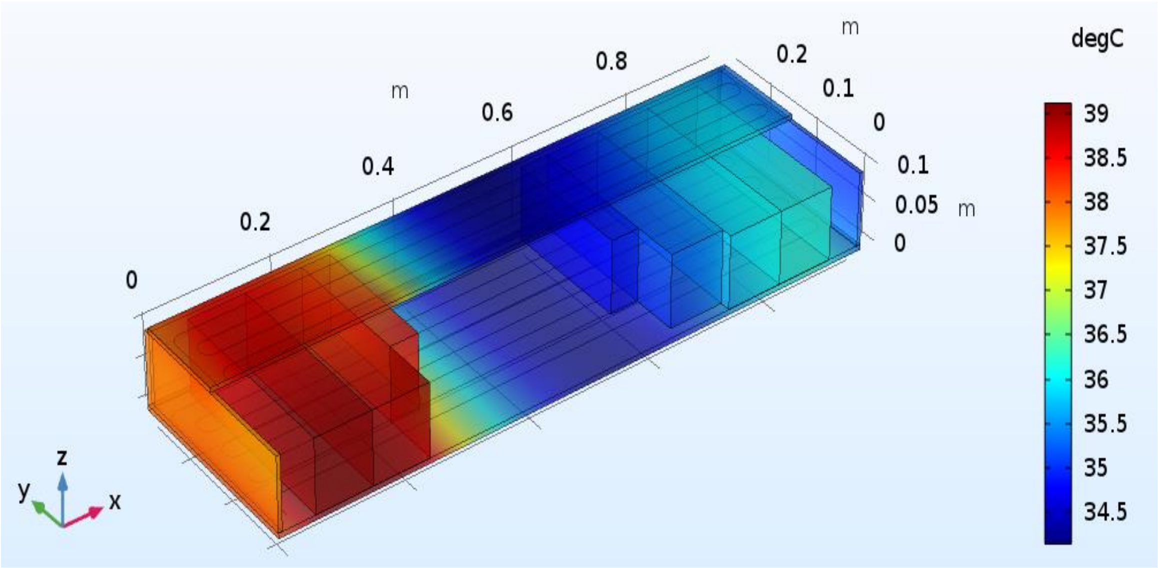


Fig.8 : System temperature distribution at t =30 [min]

PRESENT DESIGN PERFOMANCE

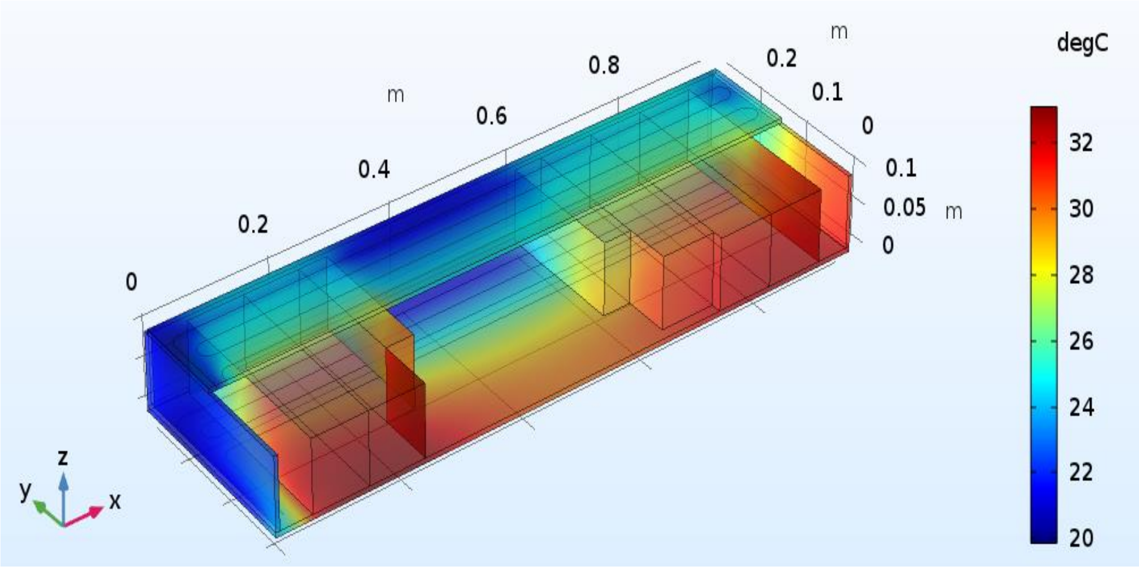


Fig.9 : System temperature distribution at t=35 [min]

Set up

Study (2 steps)

1. Time dependent (30 min/HT)
2. Time dependent (5min/Cooling system)

Summary

- Not uniform distribution
- Hot spots- cold spots

FINDINGS AND DISCUSSIONS

Analysis

Heat rate

Thermal resistances: Floor & Module

Convection resistance

$$\Delta T_{UA} = q * (2.134e-4 + \frac{9.965e-3}{L}) \Rightarrow q = UA\,\Delta T_{UA}$$

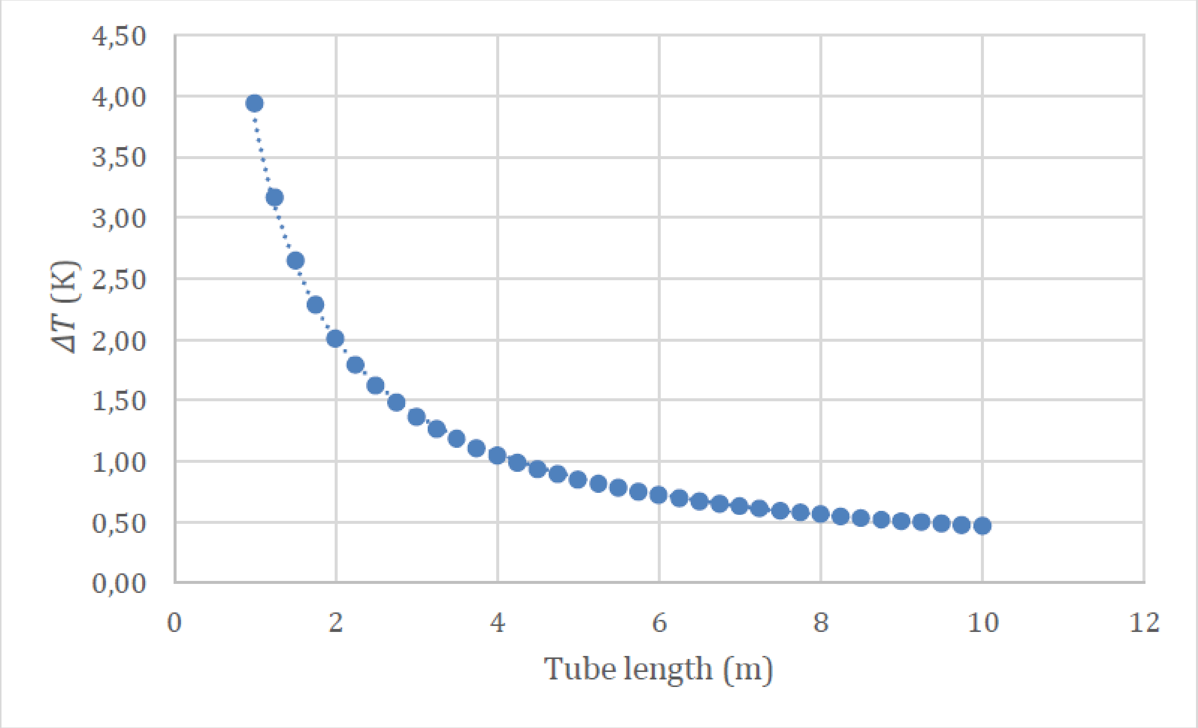


Fig.10.: Temperature vs Length

Tabla 3.: Mathematical results

Variable	Value
T_s	23.5 [°C]
T_m	20.75[[°C]
$\dot{m}$	0.0167[kg/s]
Re	6637.3
f	0.035
Nu	52.89
h	10065.6[W/(m^2K]

Summary

- As length increases, the dt decreases
- High value of heat transfer coefficient.

FLOOR & FLUID

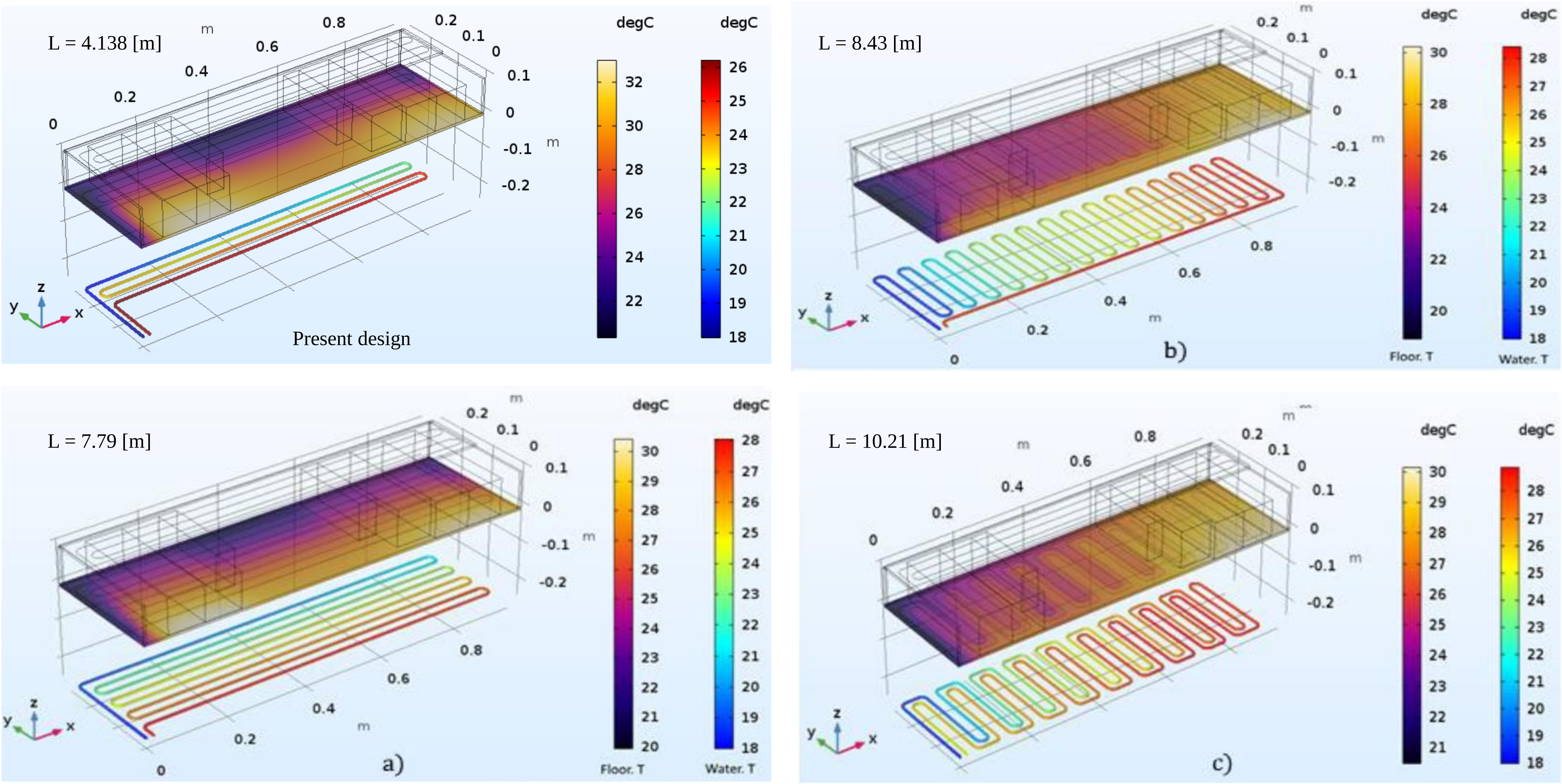


Fig.11 : Floor & Fluid temperature distribution at t =35[min]

QUANTITATIVE RESULTS

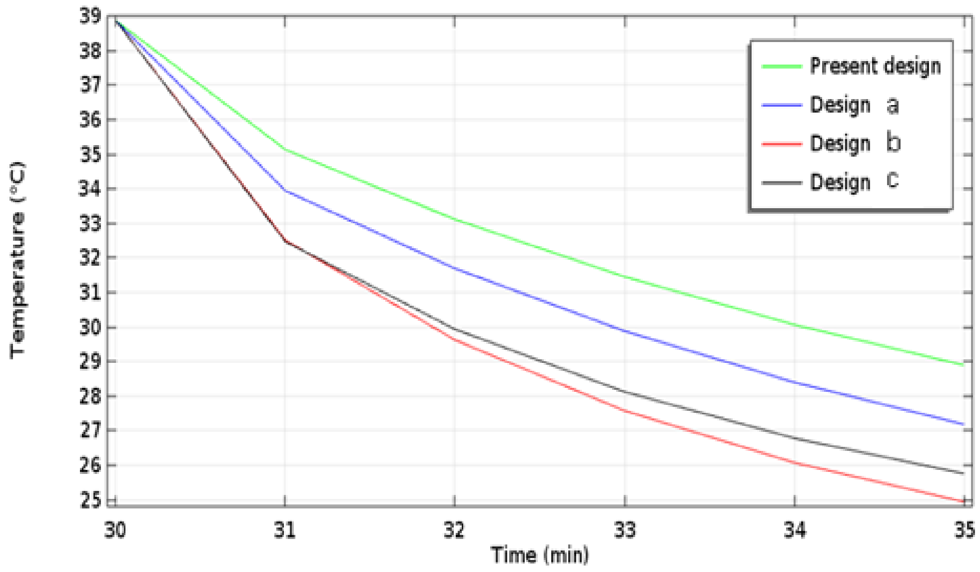


Fig.12 : Profile temperature of module (RM#1)

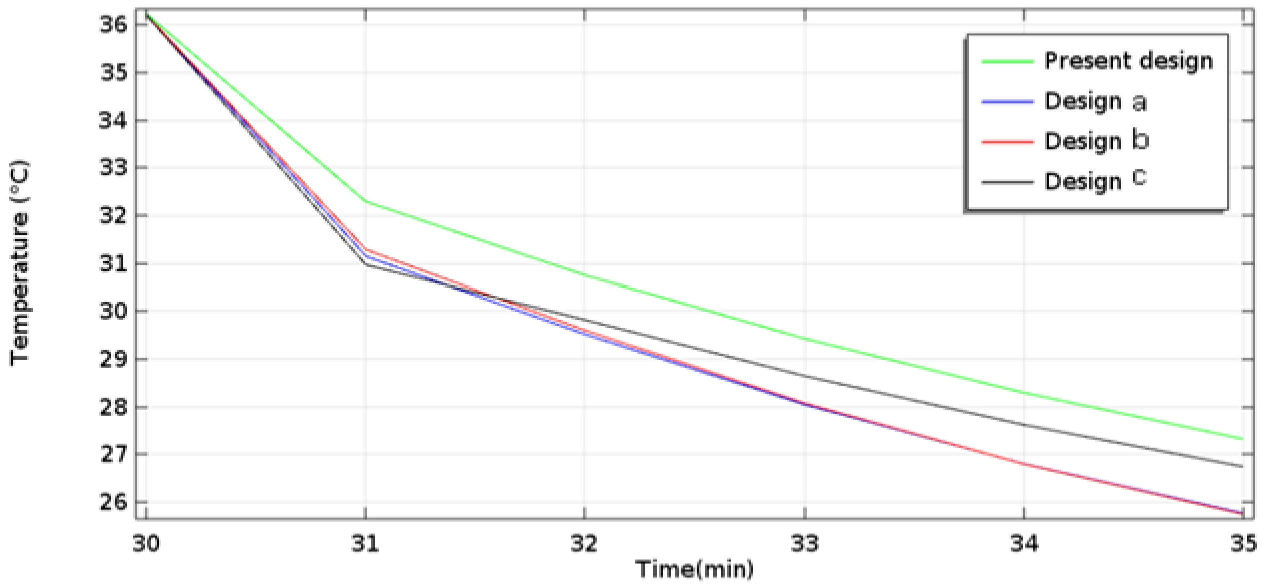


Fig.13. : Profile temperature of floor

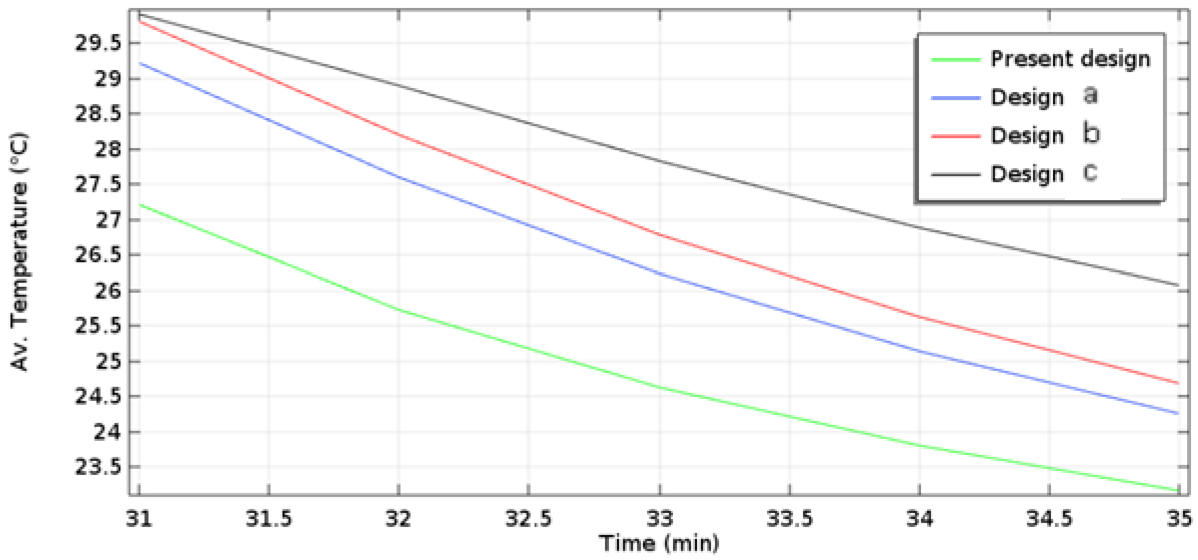


Fig.14. : Profile temperature of water

LAYOUT SELECTION

- Centralized weight method

	Criterio					
Design	Heat dissipation (5)	Feasibility (5)	Cost (3)	Fluid control(3)	∑▒+1	Total.
a	4	5	3	3	16	1,6
b	5	5	2	2	15	1,5
c	4	3	1	1	9,5	0,95
					10	1

Table 4: Selection of the best proposal

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS	RECOMMENDATIONS
A new distribution layout for the cooling system is achieved	Use the same aprroach given in Comsol (updated CADs, different liquid cooling)
Tube layout importance to enhance heat transfer	Use the same modules
Simulation analysis allow to compare different designs	
Proposal designs accomplish to reduce the temperature of floor to 26 degree C	

FUTURE WORK

1. Upgrade simulation> to get a more realistic one

- Update Cads
- Define correctly the parameters/variables.
- Integrate other heat transfer phenomenon
- Integrate extra materials & elements

- Design new proposals or remodified the current ones and evaluate them
- Select the best proposal for the cooling system

2. Build the selected proposal and test it