JOINT INSTITUTE FOR NUCLEAR RESEARCH
Veksler and Baldin laboratory of High Energy Physics

FINAL REPORT ON THE INTEREST PROGRAMME

Simulation of the air-conditioning system for the MPD-PIT.

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ABSTRACT:

NICA (**N**uclotron-based **I**on **C**ollider f**A**cility) is an accelerator complex designed to study properties of dense baryonic matter. In this facility we have MPD (**M**ulti-**P**urpose **D**etector) apparatus which is capable of detecting of charged hadrons, electrons and photons in heavy-ion collisions. For running this apparatus we need power supplying devices and some electronics which are mounted on the MPD-Platform. The MPD and Platform both are contained in the **MPD-PIT**. The MPD and the other devices need an optimum temperature to work properly. To maintain this optimum temperature we require an air conditioning system. For this project we simulated the air conditioning system to assure the optimum working of the devices in the MPD-PIT. After some simulation we came to know that the position of the air conditioner must be above the heat sources (MPD and platform) and the air conditioning system used is Mitsubishi FDT providing air flow rate of $28m^3$/min.

INTRODUCTION:

The MPD (Multi-Purpose Detector) is planned to study the properties of hot and dense nuclear matter formed during collisions of high-energy heavy ions, in particular, to search for effects associated with deconfiguration and/or restoration of chiral symmetry, to study the properties of phase transitions and mixed hadron and quark-gluon phases. The Platform contains power supplying device e Slow Control System, Detector Control System and EqDb Equipment Database for Multi-Purpose Detector in the NICA Project. The MPD and platform both releases a large amount of mount of heat which will result in higher temperature of the equipment and hence damage them. So we need an air conditioning system to maintain optimum working temperature.

After some simulations we came to know that the Mitsubishi FDT air conditioning system will be sufficient for the purpose. The position of the air conditioning system must be above the MPD and Platform.

PROJECT GOALS:

Our goal is to find the location and type of air conditioning system for maintaining the temperature of the devices. For this purpose we are using the **CFD method** using Autodesk CFD software. For the simulation we need to create a 3D model of the MPD, Platform, Rack, Hall and Pit which is done using Autodesk Inventor Professional.

SCOPE OF WORK:

In this report we can see the problem that is to find the position of the air conditioning system to maintain the optimum temperature for the MPD and other electronics, further we will be able to see the process from modelling to simulation to the conclusion.
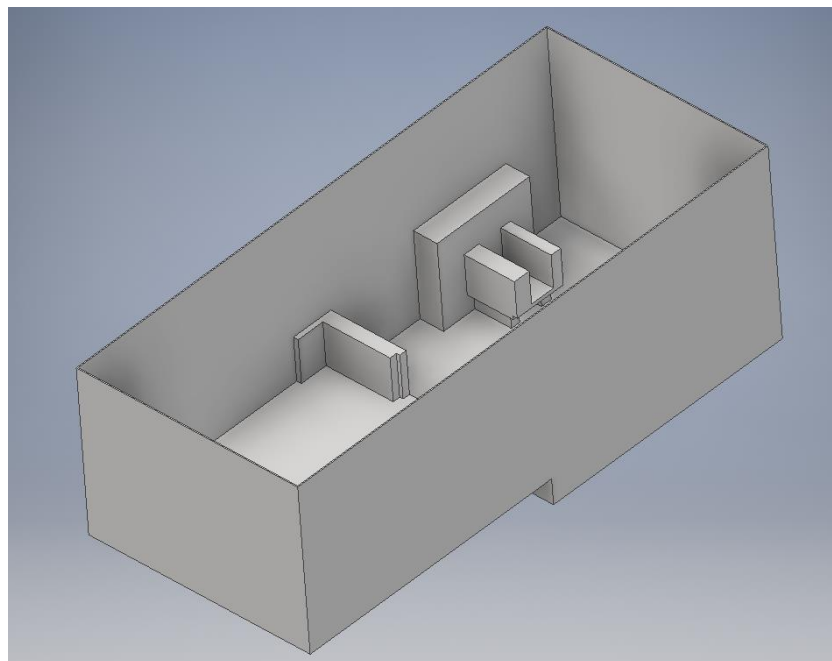
METHOD:

For conducting the simulation we need to create simple 3D models of different components. We have created simple model to reduce simulation time and errors. We are using Autodesk Inventor Professional for the modelling. The components of simulation are as follows:
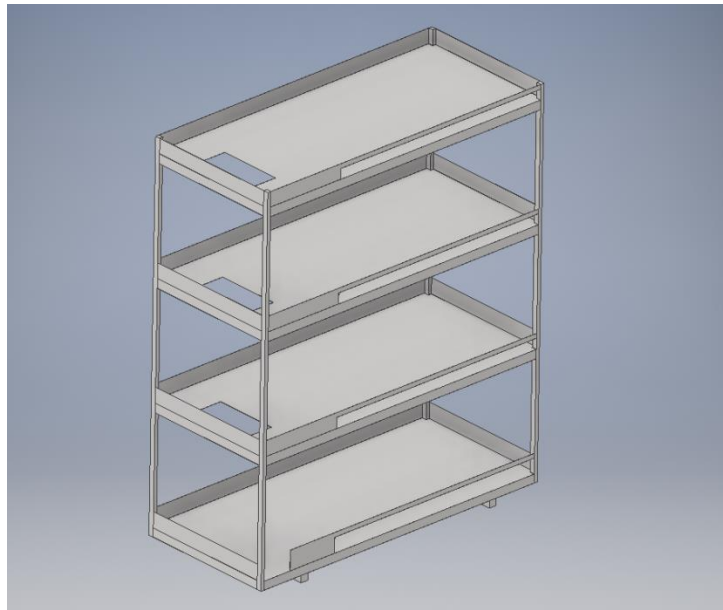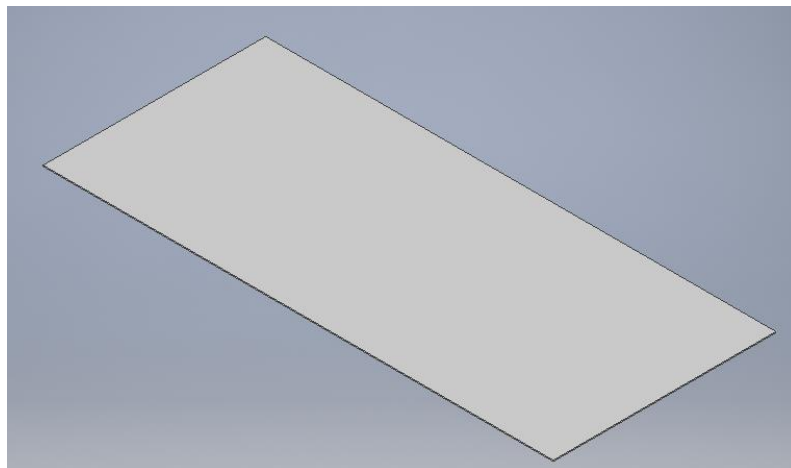
1) <u>NICA-MPD</u>:
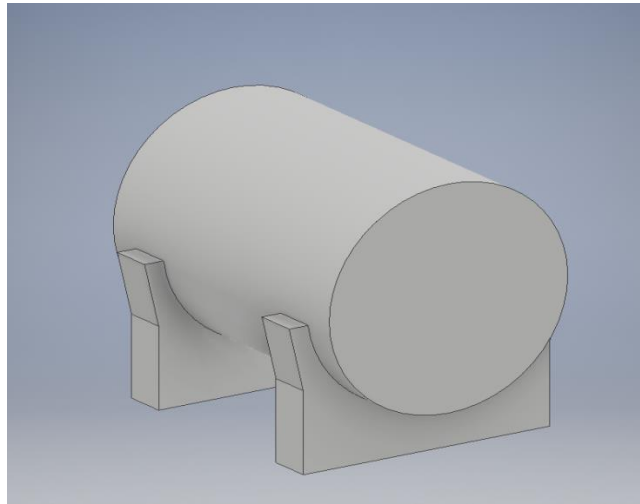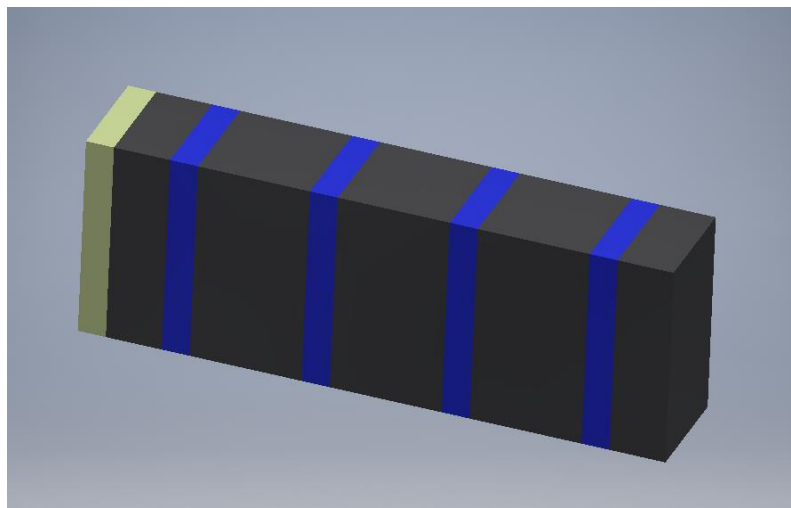

2) <u>NICA-MPD HALL</u>:
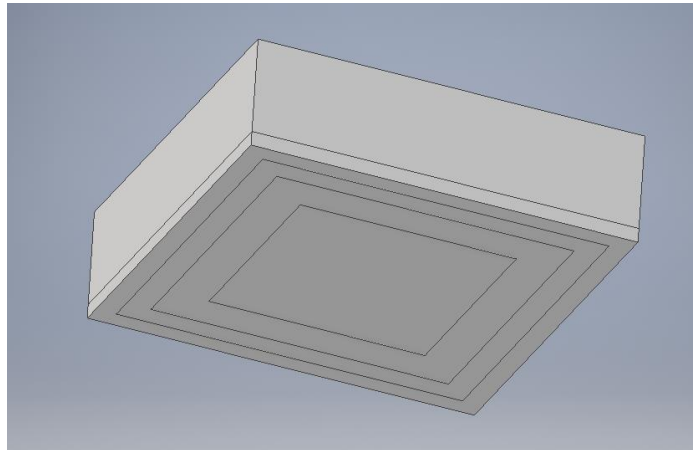
3) NICA-MPD PLATFORM:

4) ROOF:

5) RACK:

6) <u>MITSUBISHI FDT air conditioning unit</u>: I created the 3D model for the air conditioning system according to the modelling guidelines available on the Autodesk website and the dimensions are taken according to the technical document of the air conditioning system.

After assembling these components our geometry looks like this:-
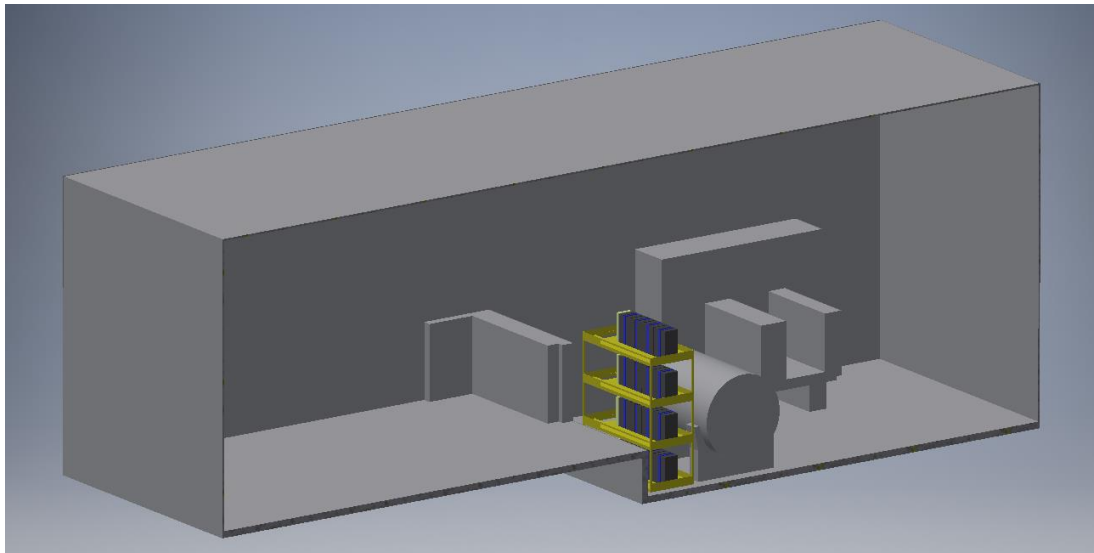
<u>Heat generation values of the Heat sources</u>:

1) NICA-MPD: 5kW.
2) RACK: 1500W.
3) AUXILLARY RACK: 100W.

Technical Specifications of the air conditioning system:-

■ **SPECIFICATIONS -FDT-**

FDT | Indoor Unit

| R32				Hyper*Inverter*			
Set model name			FDT40ZSXW1VH	FDT50ZSXW2VH	FDT60ZSXW1VH	FDT71VNXWVH	
Indoor unit			FDT40VH	FDT50VH	FDT60VH	FDT71VH	
Outdoor unit			SRC40ZSX-W1	SRC50ZSX-W2	SRC60ZSX-W1	FDC71VNX-W	
Power source			1 Phase 220-240V, 50Hz / 220V, 60Hz				
Nominal cooling capacity (Min~Max)		kW	4.0 (1.1 ~ 4.7)	5.0 (1.1 ~ 5.6)	5.6 (1.1 ~ 6.3)	7.1 (3.2 ~ 8.0)	
Nominal heating capacity (Min~Max)		kW	4.5 (0.6 ~ 5.4)	5.4 (0.6 ~ 6.3)	6.7 (0.6 ~ 6.7)	8.0 (3.6 ~ 9.0)	
Power consumption	Cooling/Heating	kW	0.890 / 1.03	1.29 / 1.31	1.33 / 1.56	1.69 / 1.75	
EER/COP	Cooling/Heating		4.49 / 4.37	3.88 / 4.12	4.21 / 4.29	4.20 / 4.58	
Inrush current		A	5	5	5	5	
Max. current			15	15	15	19.1	
Sound power level*1	Indoor	Cooling/Heating	50 / 50	55 / 56	58 / 59	59 / 60	
	Outdoor	Cooling/Heating	63 / 62	63 / 62	65 / 65	66 / 66	
Sound pressure level*1	Indoor	Cooling (P-Hi/Hi/Me/Lo)	dB(A)	36 / 33 / 30 / 26	41 / 33 / 30 / 26	44 / 34 / 30 / 27	46 / 34 / 31 / 26
		Heating (P-Hi/Hi/Me/Lo)		36 / 33 / 28 / 20	42 / 33 / 28 / 20	44 / 34 / 30 / 23	46 / 34 / 31 / 26
	Outdoor	Cooling/Heating		52 / 50	52 / 50	53 / 54	51 / 51
Air flow	Indoor	Cooling (P-Hi/Hi/Me/Lo)	m³/min	19 / 16 / 13 / 10	22 / 16 / 13 / 10	26 / 17 / 14 / 11	28 / 18 / 15 / 12
		Heating (P-Hi/Hi/Me/Lo)		19 / 16 / 13 / 10	22 / 16 / 13 / 10	26 / 17 / 14 / 11	28 / 18 / 15 / 12
	Outdoor	Cooling/Heating		33 / 33	39 / 33	41.5 / 39	60 / 50
Exterior dimensions	Indoor	HeightxWidthxDepth	mm	Unit: 236 x 840 x 840 Panel: 35 x 950 x 950			
	Outdoor			640 x 800(+71) x 290			750 x 880(+88) x 340
Net weight	Indoor		kg	24(Unit:19 Standard Panel:5)		26(Unit:21 Standard Panel:5)	
	Outdoor			45			60	
Ref.piping size	Liquid/Gas	ømm	6.35(1/4") / 12.7(1/2")			9.52(3/8") / 15.88(5/8")	
Refrigerant line (one way) length		m	Max.30			Max.50	
Vertical height differences	Outdoor is higher/lower	m	Max.20 / Max.20			Max.30 / Max.15	
Outdoor operating temperature range	Cooling	°C	-15~46*2			-15~50*2	
	Heating		-20~24			-20~20	
Panel			T-PSA-5BW-E, T-PSAE-5BW-E(White) / T-PSA-5BB-E, T-PSAE-5BB-E(Black)				
Air filter, Q'ty			Pocket plastic net x 1(Washable)				
Remote control (option)			wired:RC-EX3A, RC-E5, RCH-E3 wireless:RCN-T-5AW-E2, RCN-T-5BW-E2				

Before proceeding to the actual simulation we have conducted some practice simulations as follows:

**1) PCB simulation with forced convection through fan:**

We have conducted a CFD simulation over a pcb with chip and heat sink with forced convection with the help of a fan. Forced convection is used to reduce the temperature of the chip so that it can not cross the temperature limit.

We got the temperature under control with the help of forced convection using a fan that can be seen in the results below:
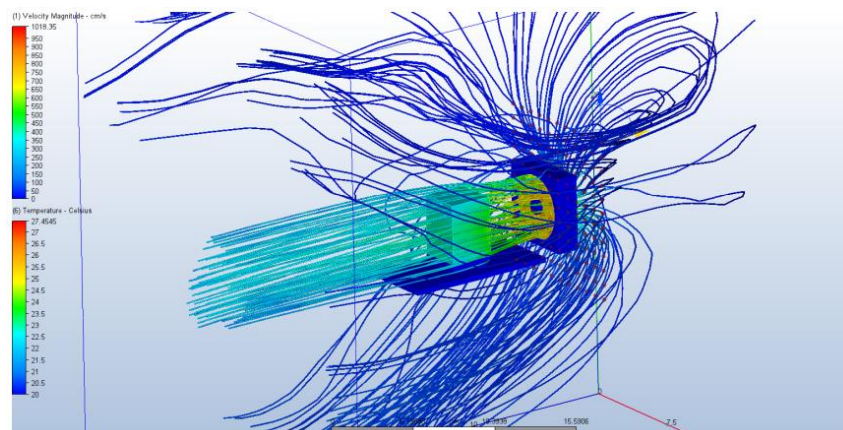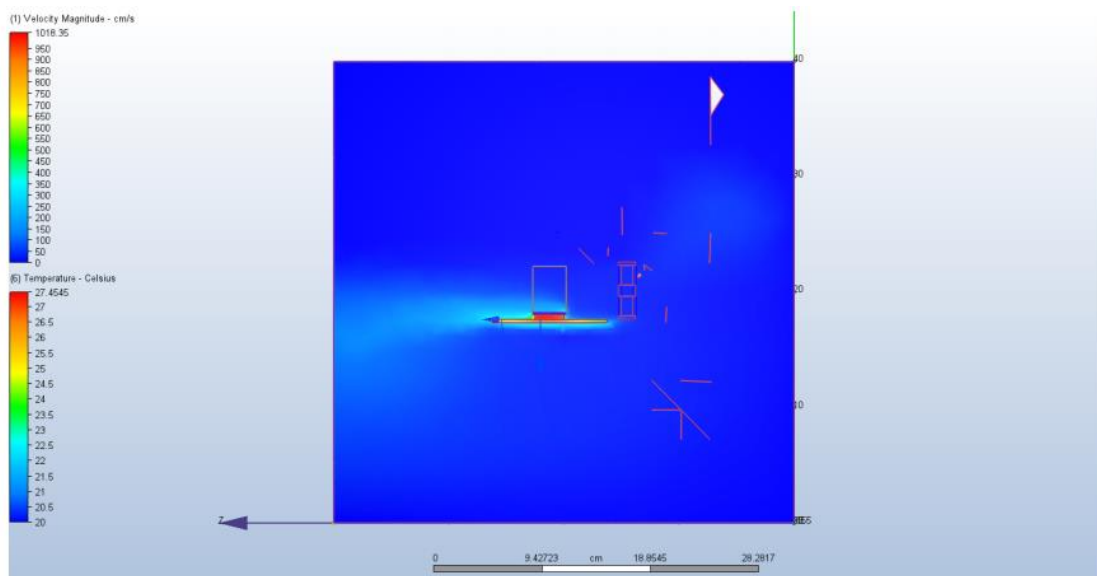
We are getting the graph of temperature through PCB as follows:
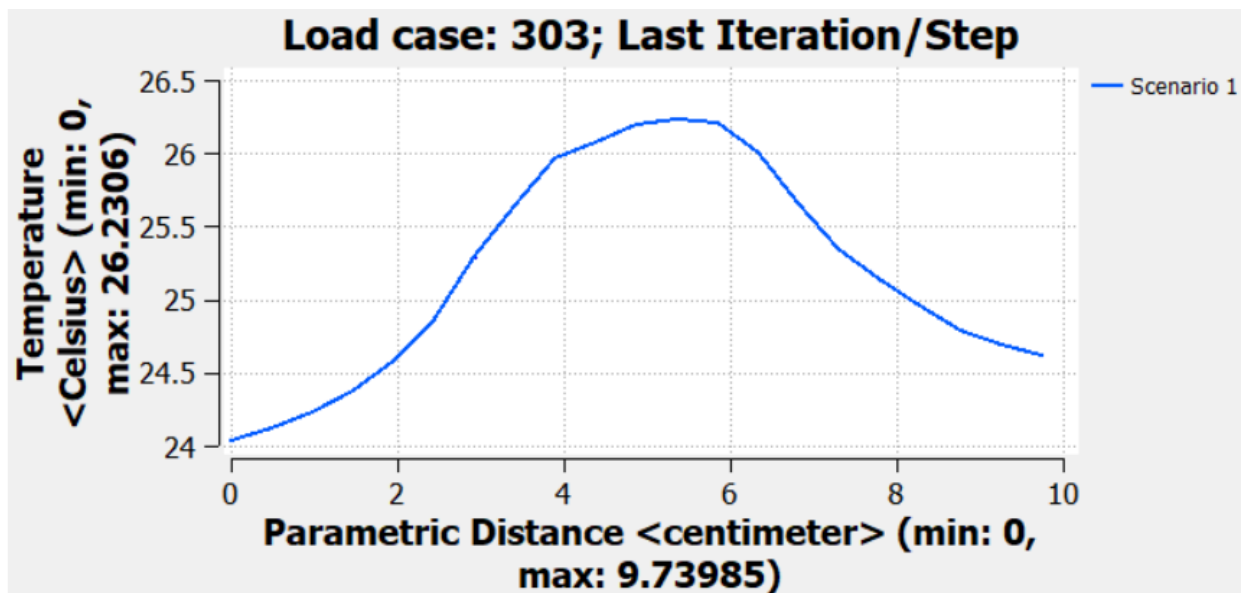
Now proceeding towards the main simulation we have to choose our heat exchanger material in the Autodesk CFD software for conducting the simulation. For this material we have to choose the model type among the following options:

Heat Exchanger Type	Governing Equation	Boundary Condition at Heat Exchanger Inlet	Boundary Condition at Heat Exchanger Outlet
Heat Exchanger (q'', T_∞)	$q = c'(T_m - T_\infty) = \dot{m}C_p(T_{out} - T_\infty)$	$p = 0$	$T_{out} = \frac{q''}{\dot{m}C_p}(T_{in} - T_\infty) + T_{in}$
Heat Input/Extraction Rate (Q)	$Q = \dot{m}C_p(T_{out} - T_{in})$	$p = 0$	$T_{out} = T_{in} + \frac{Q}{\dot{m}C_p}$
Temperature Change (∇)	$\nabla = T_{out} - T_{in}$	$p = 0$	$T_{out} = T_{in} + \nabla$
Air Conditioner $(Tset)$	$T_{out} = T_{set}$	$p = 0$	$T_{out} = T_{set}$

We have selected the Air conditioner type of model as it suited our interest because in this type we can choose the desired outlet temperature of the air flow and can also get the heat extracted from the system.

To get some hold on this type of heat exchanger material we created a simple simulation model with some heat sources and a heat exchanger enclosed in a room.

According to the size of the room we have selected the air flow rate through the heat exchanger to be $0.1\text{m}^3/\text{min}$ and the temperature of the air flow at the outlet of the heat exchanger to be $20\,^0\text{C}$. After conducted the simulation we came to know that the temperatures are under control.

The simulation results are as follows:
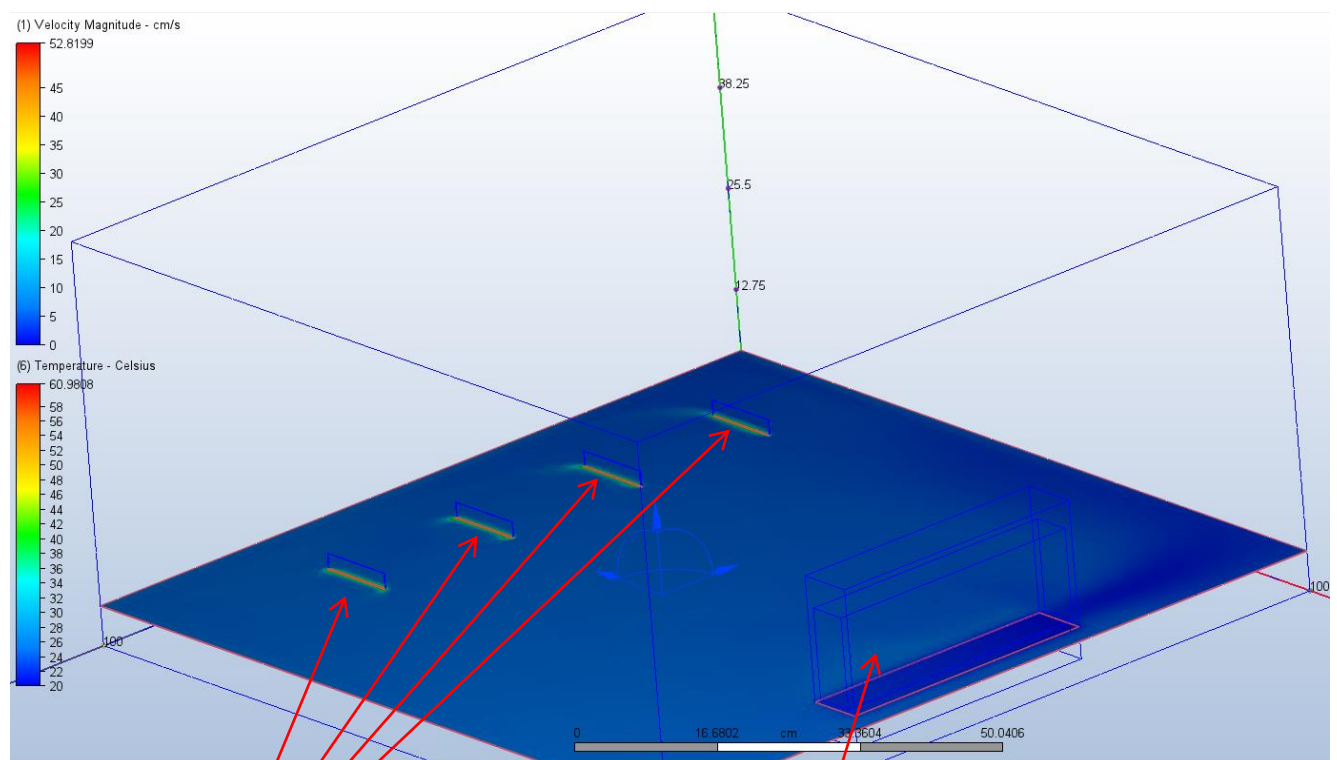
HEAT EXCHANGER
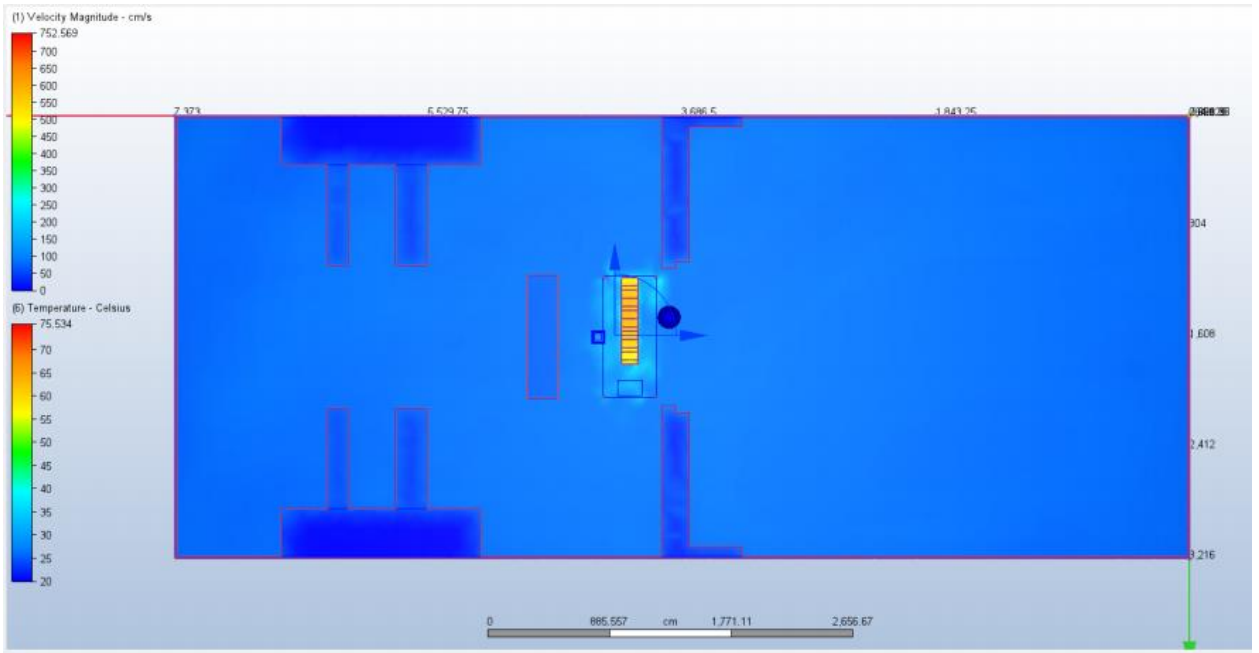
HEAT SOURCES

RESULTS:

Now after getting the hold on the heat exchanger material we finally conducted the simulation for the actual model.

For the simulation we are supposed to choose the position for the heat exchanger and the proposed position is above the MPD AND PLATFORM so that it can intake hot air before it gets around the pit.
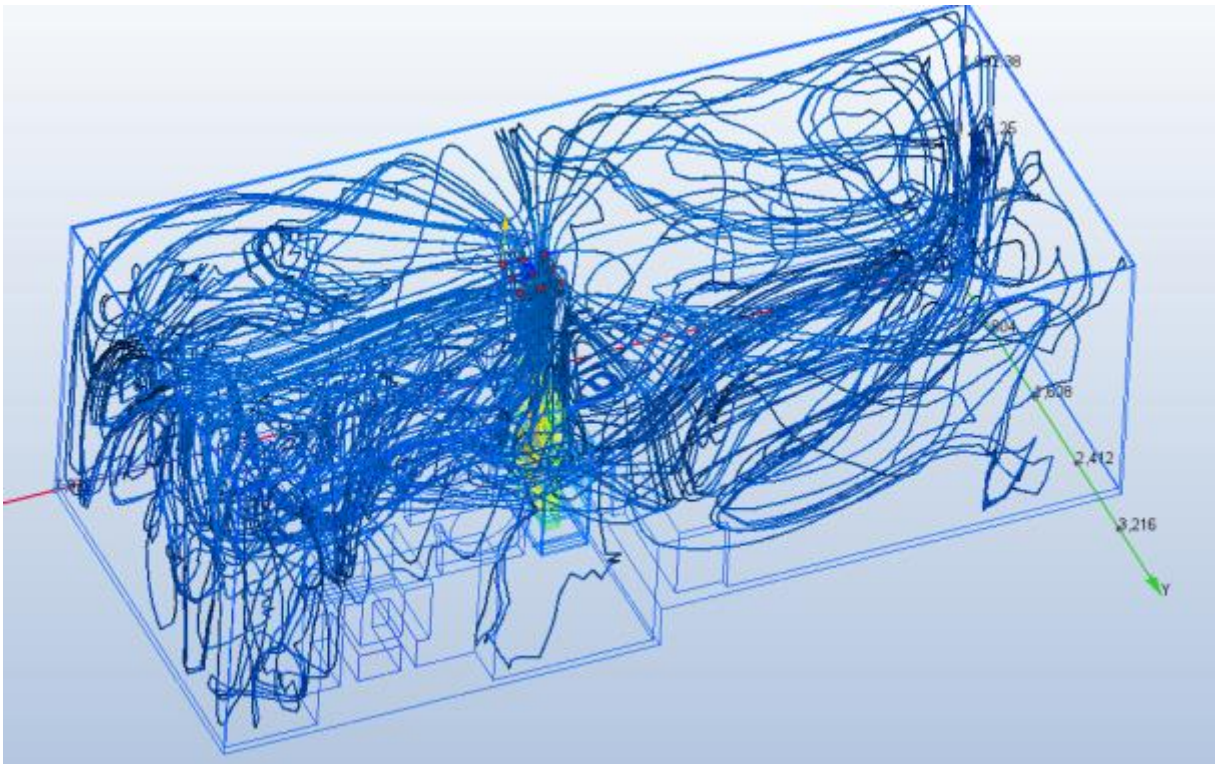
The results came out as follows:-

Some cross sections for the temperatures through the geometry:
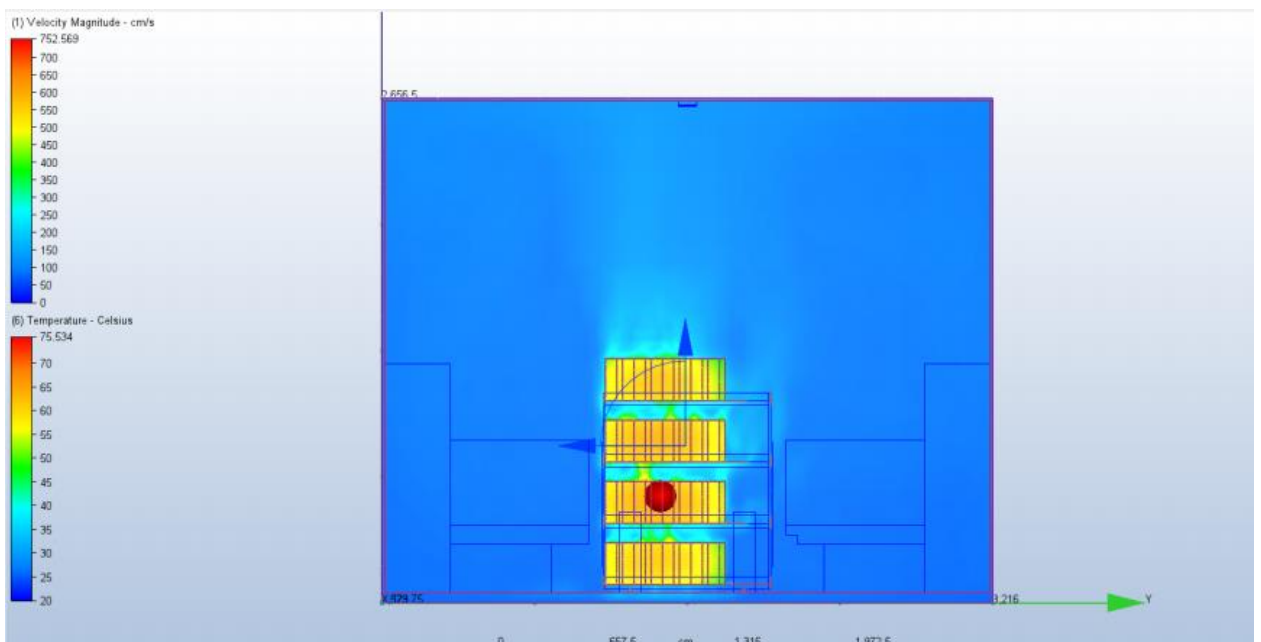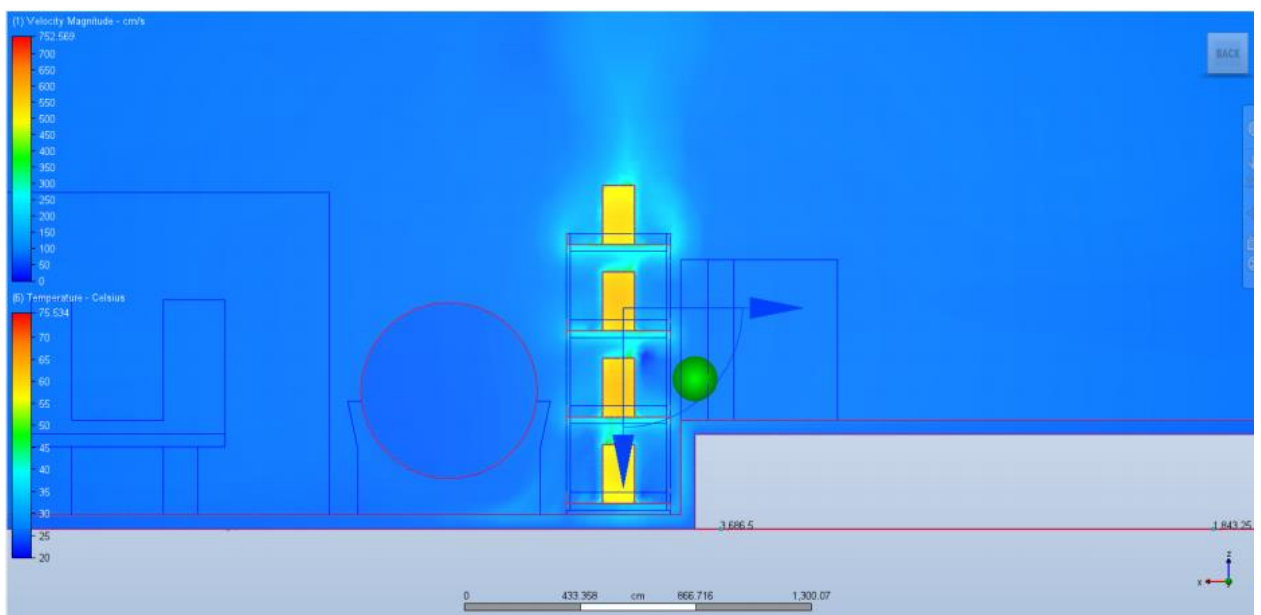
Traces of the air passing through a plane near the air conditioning system:

CONCLUSION:

The position that is above the heat sources (MPD and Platform) and type of air conditioning system that is Mitsubishi FDT with flow rate of 28 m ^{3}/min is appropriate and can be used in actual environment as the temperatures are under control (max temperature is approx. 76^{0}C) and the flow is covering the MPD and the PLATFORM containing racks and does not leave any part isolated from the flow.

REFERANCES:

1) https://nica.jinr.ru/

2) https://nica.jinr.ru/ru/projects/mpd.php

3) https://knowledge.autodesk.com/support/cfd/learn-explore/caas/CloudHelp/cloudhelp/2019/ENU/SimCFD-UsersGuide/files/GUID-E3874AC0-9E73-418B-8078-E48C052DFBC1-htm.html

4) https://knowledge.autodesk.com/support/cfd/learn-explore/caas/CloudHelp/cloudhelp/2019/ENU/SimCFD-UsersGuide/files/GUID-7484B9BE-E25A-4B2A-AD3A-7880395A8E45-htm.html

5) https://knowledge.autodesk.com/support/cfd/learn-explore/caas/CloudHelp/cloudhelp/2019/ENU/SimCFD-UsersGuide/files/GUID-853964E6-6891-4BC6-97E0-F924A0B83BB6-htm.html

ACKNOWLEDGMENT: