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

FINAL REPORT ON THE INTEREST PROGRAMME

Simulation of the heat generated by the NICA-MPD-Platform

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Abstract

Simulations of NICA-MPD Platform were performed in order to asses heat transfer properties of the design. Simple 3D model and heat transfer simulations were prepared and air particles trajectory visualized.

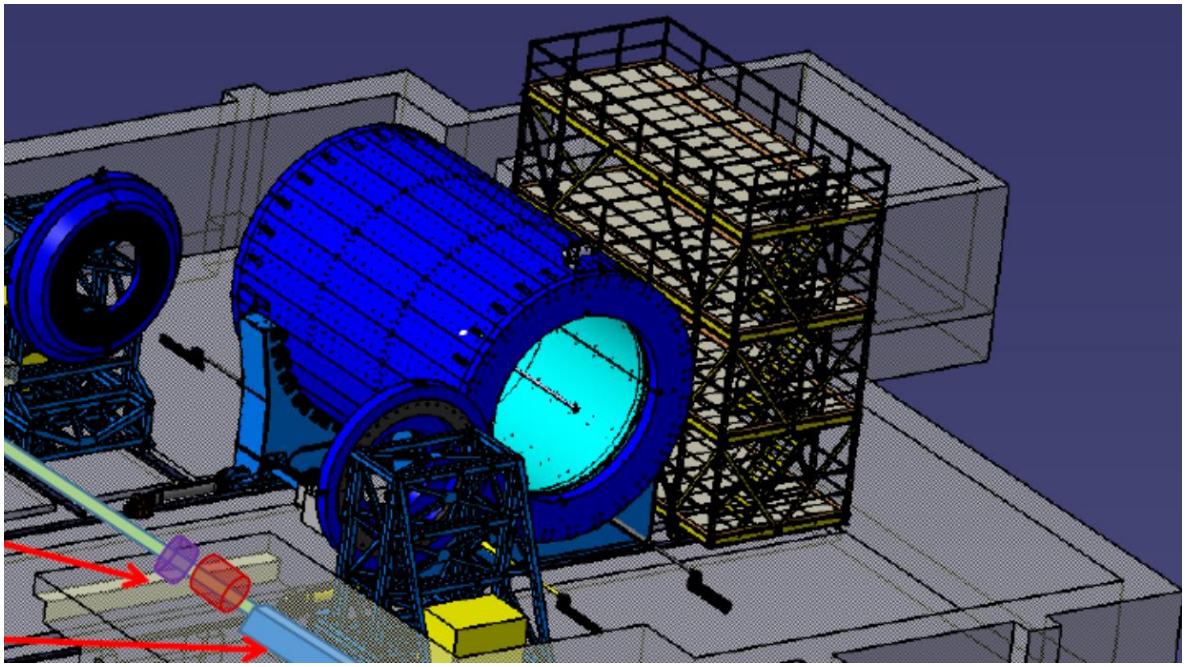
Introduction

JINR Joint **I**nstitute for **N**uclear **R**esearch in Dubna, a project called **NICA N**uclotron-based **I**on **C**ollider f**A**cility is being implemented to create an ionic collider based on the Nuclotron as part of a program to study nuclear matter in a hot and dense state. The main objectives of the program: the creation of an accelerator complex of ions with high luminosity in the energy range up to 11 GeV/nucleon and a modern multi-functional detector for the study of heavy ion collisions.

The collider has two meeting points for the beams, which makes it possible to install two detectors and simultaneously carry out two experiments. One of the detectors, the **MPD M**ulti-**P**urpose **D**etector, 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 NICA complex includes various types of accelerators: a linear accelerator, an intermediate energy storage accelerator (booster), the Nuclotron and a collider. These accelerators provide beams in the energy range E_{lab} = 1 – 4,5 AGeV and are required in many applied research programs. The planned accelerator-accumulative complex will open up new great opportunities for carrying out applied programs, radiation technologies, biology and medicine at JINR.

An important goal of the NICA project is to provide users with a research machine that will allow them to acquire new scientific knowledge, research and understand the physical properties of a substance at an early stage of its occurrence.



PLATFORM MPD-NICA and MPD, Mechanical Design

Background

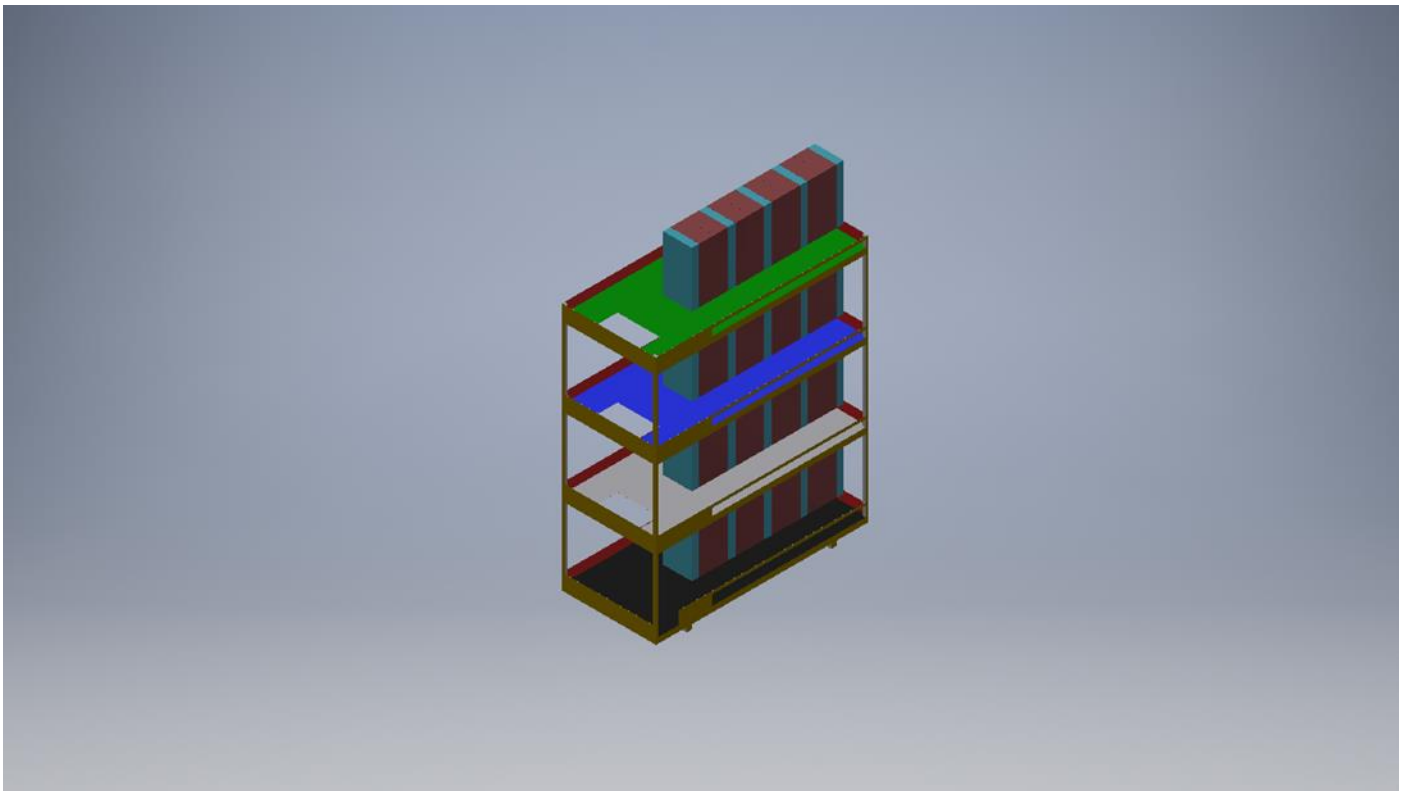
The multi-functional detector MPD is an advanced technical device with many parameters and features that require constant monitoring and control in on-line mode. Therefore, the MPD construction requires designing and execution of dedicated technical installations using advanced technologies that will meet the task.

Service requirements for MPD, made it an integrated structure placed on the wagon, allowing the entire module to be moved within 11 meters for service purposes. Many transmission paths, a high data rate required, limits the installation space. Therefore, the MPD control room will be placed on a special mechanical structure in four floors. In this design, there will be 32 RACKS install the MPD infrastructure.

NICA-MPD-PLATFORM is designed as a mobile device integrated with MPD. The expected weight of the wagon is about 150 T.

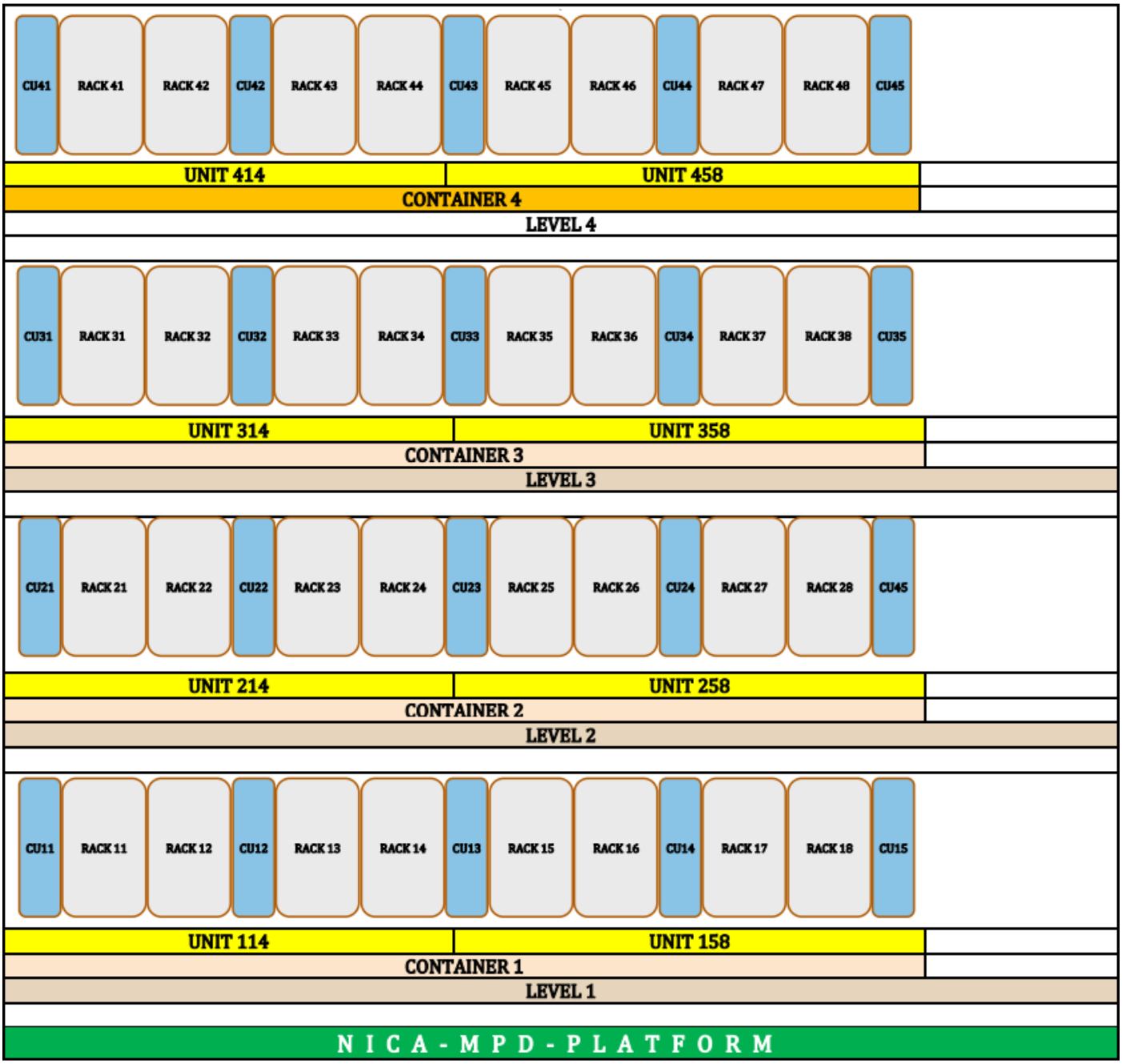
The MPD-NICA platform has 4 floors. The lowest, LEVEL 1 (Black Color), is intended for power equipment, supplying MPD and the Platform itself.

The next three LEVELs [2 (Grey Color), 3 (Blue Color), 4 (Green Color)] are for the **SSC S**low **C**ontrol **S**ystem and **DCS D**etector **C**ontrol **S**ystem, for the MPD-NICA project.



Geometry Model of PLATFORM MPD-NICA

- RACK: the basic object of the NICA-MPD-PLATFORM
- AUXILIARY RACK - COOLING UNIT: five units per CONTAINER
- UNIT: four RACK’s
- CONTAINERS: two UNIT’s, eight RACKs
- PLATFORM: four LEVEL’s, eight UNIT’s, thirty-two RACK’s



PLATFORM MPD-NICA Architecture

RACK: -

RACK dimensions are 600x1200x2200(mm). It is supported by a 300x1200x2200(mm) construction in auxiliary systems, COOLING UNIT such as VAC, Ventilating and Air Conditioning, as well as other required ones. Therefore, the real dimensions of a single RACK are 900x1200x2200(mm). Some supporting modules can support two RACKs. In such cases, the dimensions should be estimated individually.

AUXILIARY RACK - COOLING UNIT: -

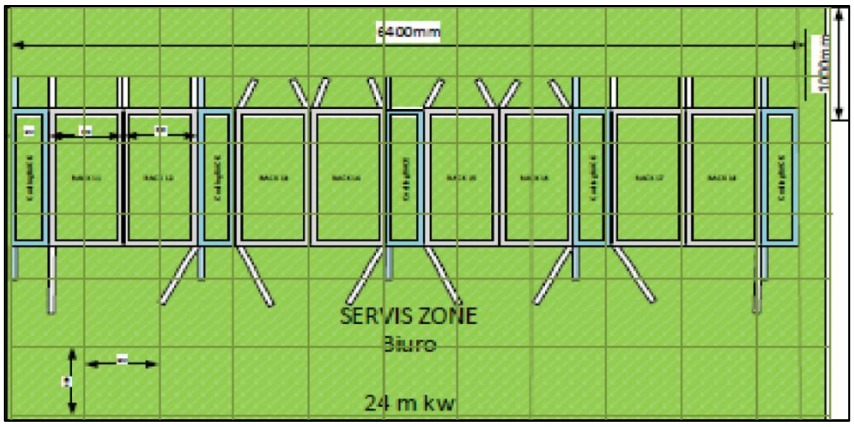
There are five units per container. It contains Ventilating and Air Conditioning (VAC)

UNIT: -

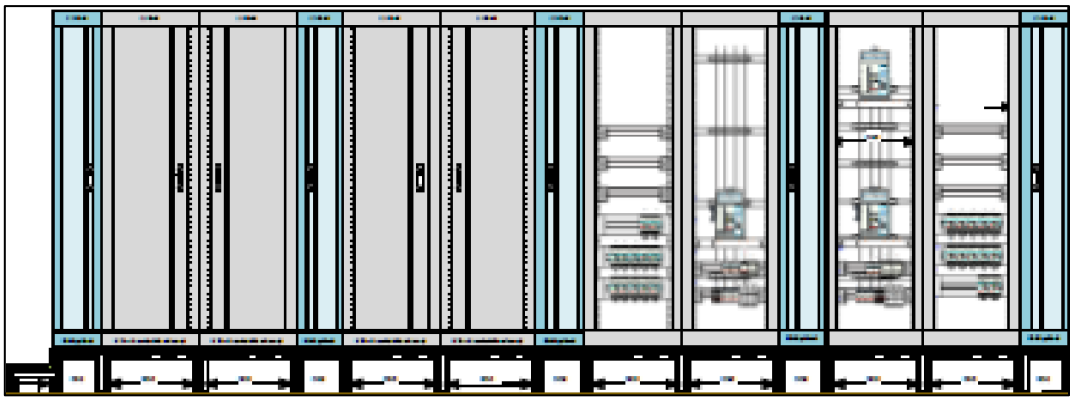
UNIT is a mechanical structure consisting of four completely standard RACKs and necessary AUXILIARY RACK - COOLING UNIT: such as VAC, Ventilating and Air Conditioning.

CONTAINER: -

The CONTAINER is two UNITs or eight RACKs and five AUXILIARY RACK - COOLING UNIT. Height of a CONTAINER is 3000mm.



PLATFORM MPD-NICA RACK Containers Top View



PLATFORM MPD-NICA RACK Containers Front View

Project Goals

1. Understand overall design of NICA-MPD-Platform.
2. Learn Autodesk Inventor Pro to create simple 3D geometry.
3. Learn Autodesk CFD to conduct heat transfer and gas flow simulations.
4. Prepare a simplified geometry model of a NICA-MPD-Platform with Racks.
5. Conduct a heat transfer simulation for the model of typical NICA-MPD-Platform.

Method

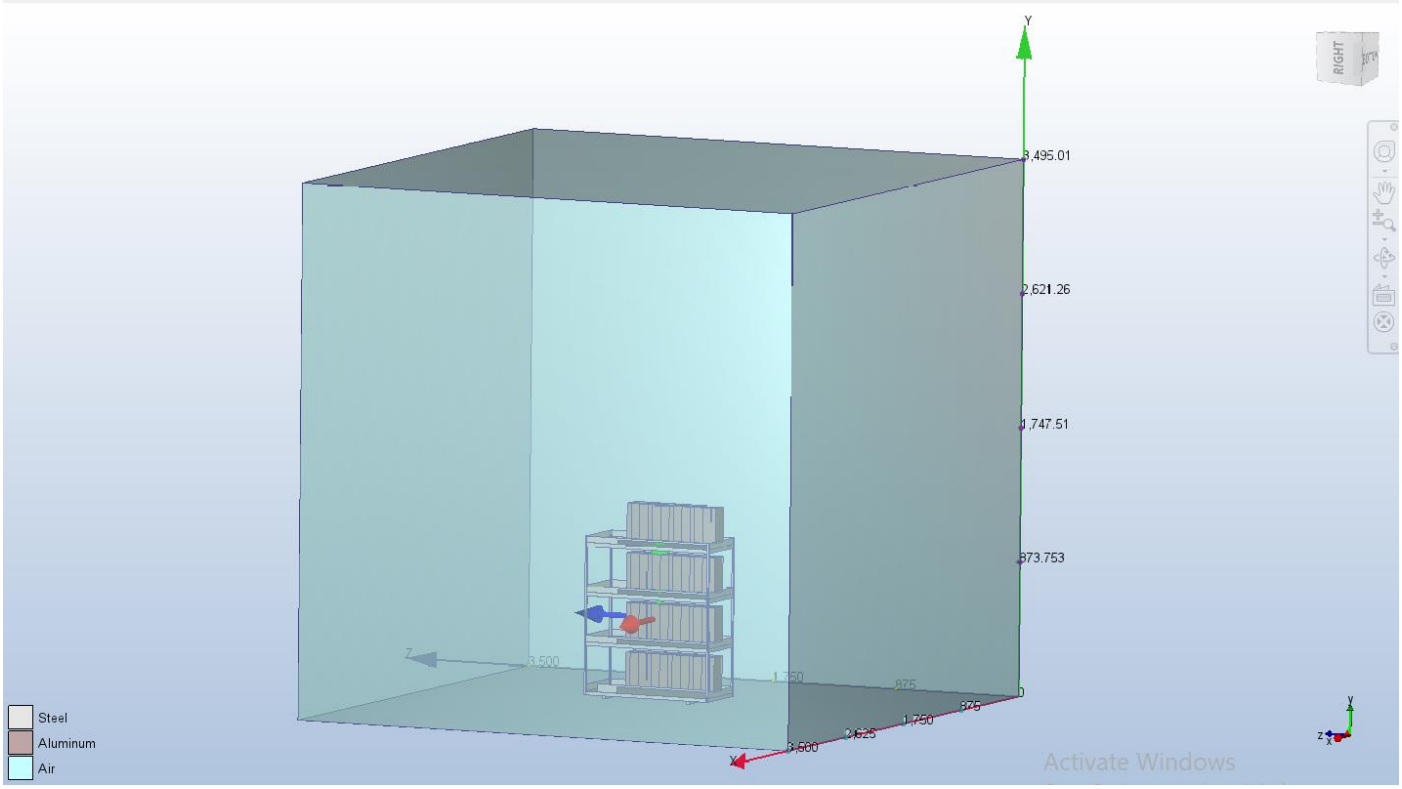
1. Draw different parts of NICA-MPD-Platform, i.e., Rack, Cooling Unit, simplified Platform design using Autodesk Inventor Pro.
2. Assemble all the parts in Autodesk Inventor Pro as pre the real design of Platform.
3. Open the assembly in Autodesk CFD.
4. Set external volume with dimensions 3500x3500x3500(cm).
5. Fill the volume with air as a variable component in the environment.
6. Set Material of Construction (MOC) of Rack & Platform as aluminum & steel respectively.
7. Set Boundary Conditions for the environment.
8. Set Mesh Sizing as auto size.
9. Click on Solve Simulation.
10. Enable heat transfer & auto forced convection, set gravity as per the environment.

Set-Up

External volume – 3500x3500x3500 (Air, variable)

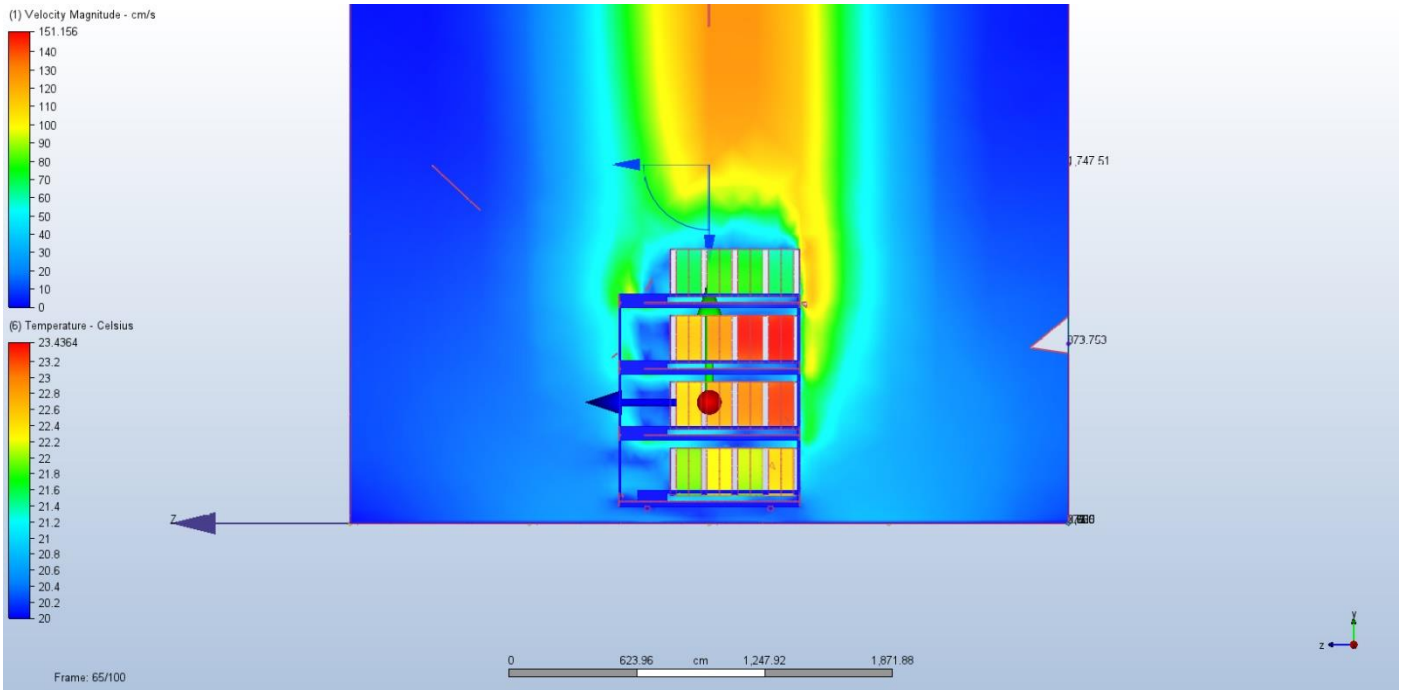
Material of Construction: Platform – Steel
Racks (including Cooling Units) – Aluminum

Boundary Conditions: Walls (5 & including floor) – Temperature = 20℃
Walls (5) – Pressure = 0 Pa Gage
Racks (Front, Back & Top Surface) – Heat Flux = 20 W/m^2

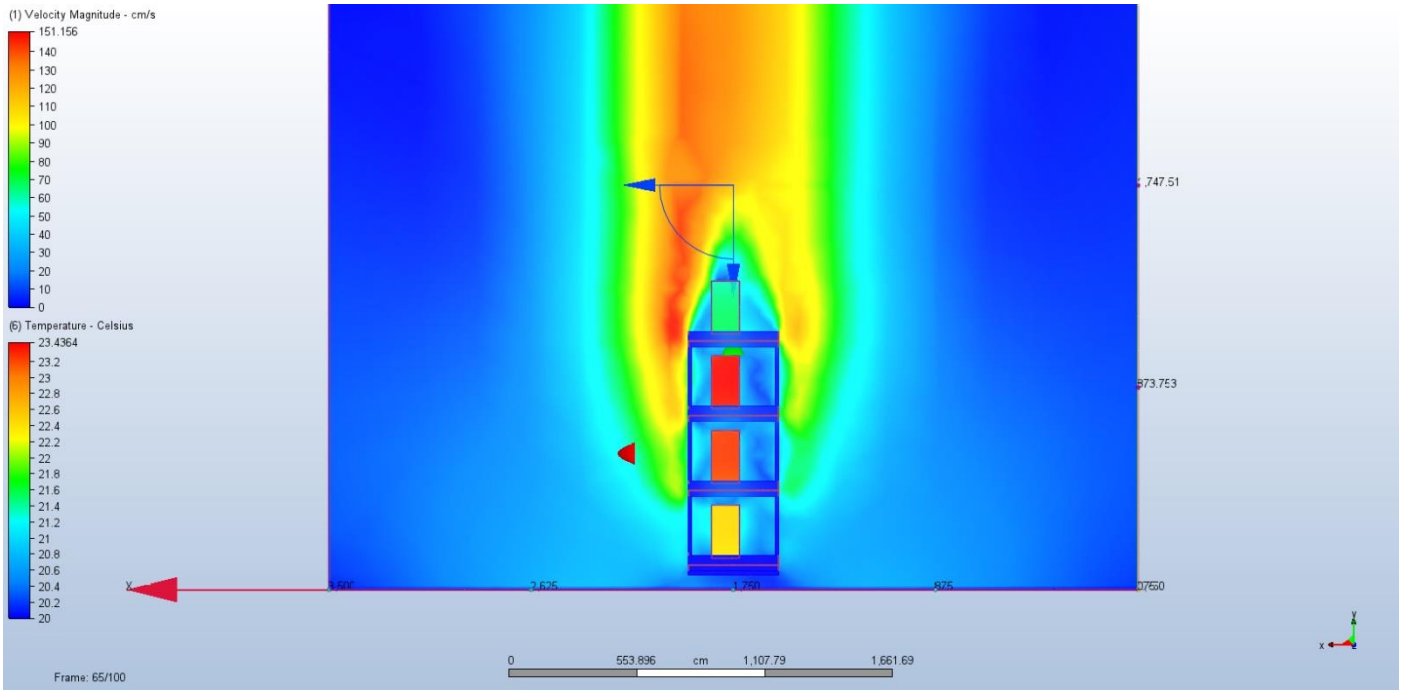


Autodesk CFD Set-Up for Platform

Results

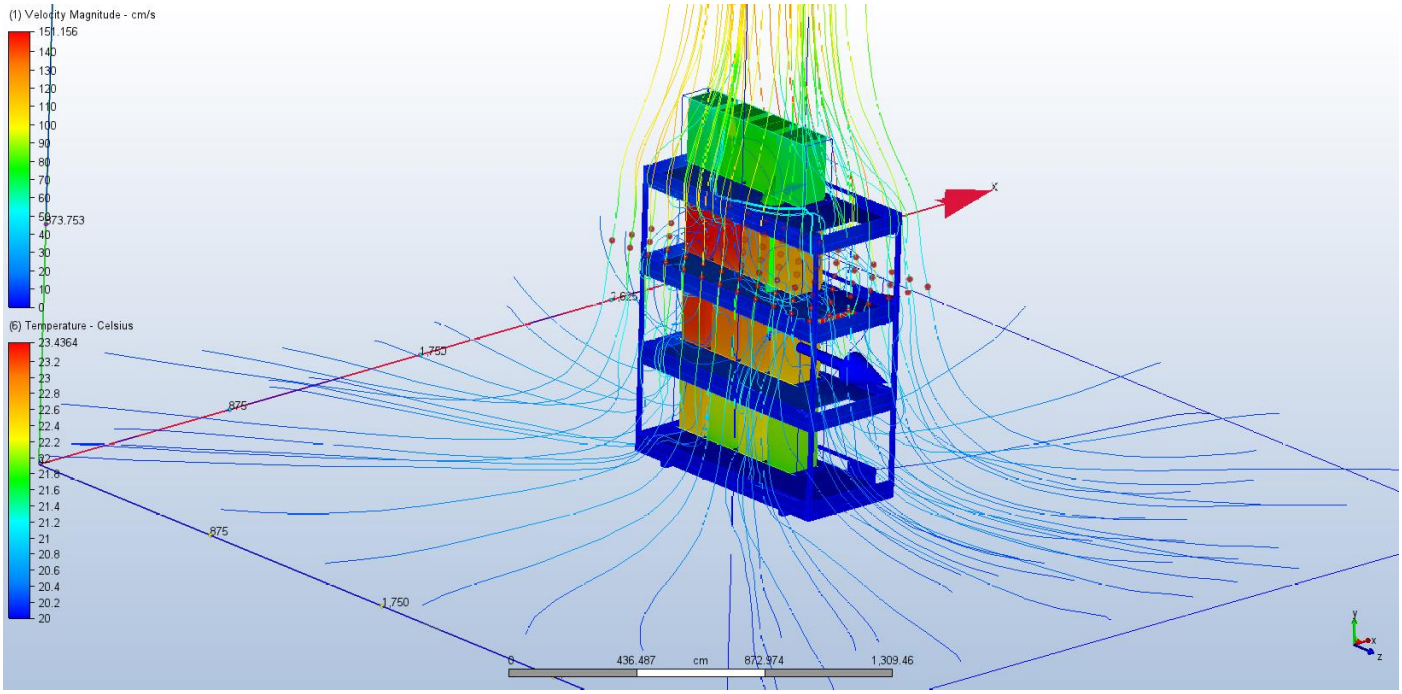


PLATFORM Side View (Figure 1)

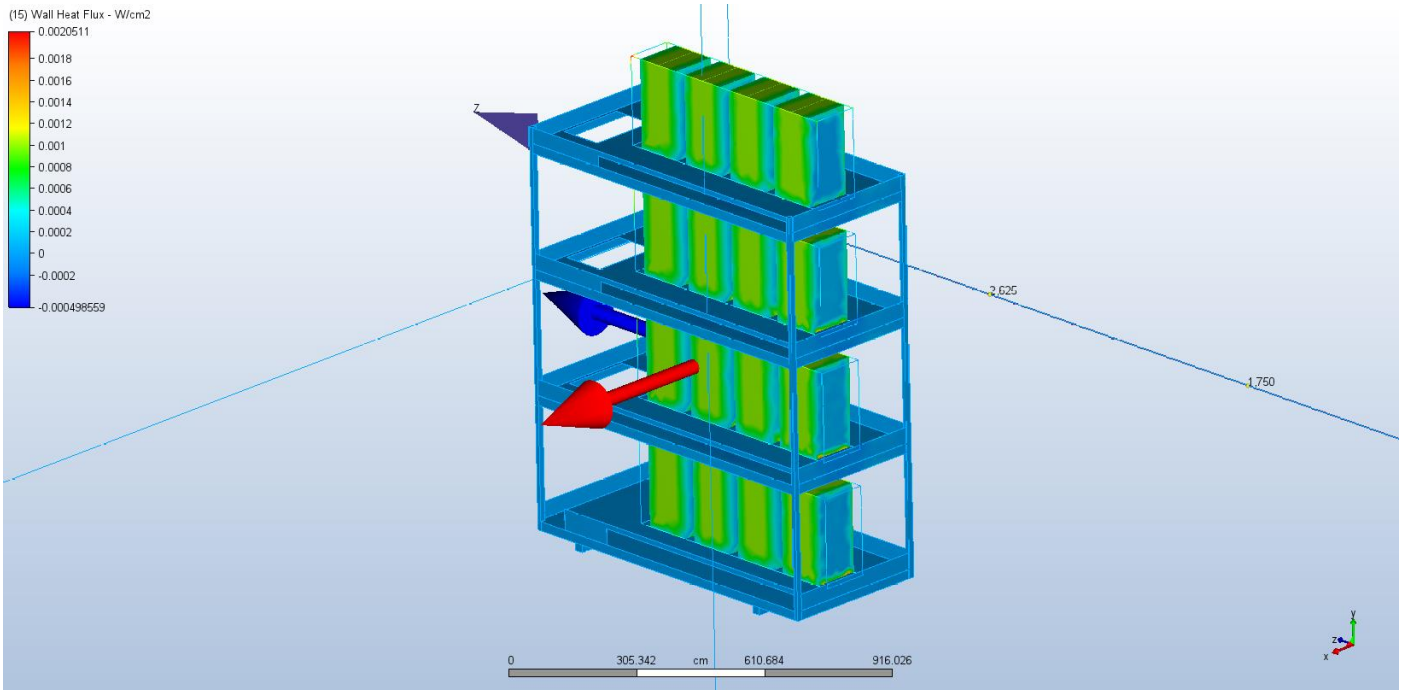


PLATFORM Back View (Figure 2)

Heat generated by Rack: Maximum – 23.5℃
Average – 22℃
Minimum – 21.5℃



PLATFORM Air Flow (Figure 3)



PLATFORM Wall Heat Flux (Figure 4)

Conclusion

The analysis of heat simulation helps us to know heat generated by each Rack and air flow in surroundings of NICA-MPD Platform.

We can see that there surrounding of NICA-MPD Platform should well ventilate as heat could affect performance of MPD detector and system inside NICA-MPD Platform during experiment.

References

1. Autodesk Inventor Pro & Autodesk CFD: -

   (https://www.autodesk.com/education/edu-software/overview?sorting=featured&page=1)

2. Autodesk CFD Support & Learning :-
   (https://knowledge.autodesk.com/support/cfd/getting-started/caas/CloudHelp/cloudhelp/2019/ENU/SimCFD-QuickStart/files/GUID-F9435F15-8684-4FD5-A329-E6EC8B45B640-htm.html)

3. TDR NICA_MPD_PLATFORM: -
   (http://mpd.jinr.ru/wp-content/uploads/2019/10/TDR_NICA-MPD-PLATFORM_EN_190520.pdf)

Acknowledgement

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I would be grateful to Joint Institute of Nuclear research, Dubna for such an initiative which connects students all over the world to such great scientists without travelling and to work on such projects.

Thanks and Regards!
Om Upadhye

Thank You