SYSTEM OF TEMPERATURE REGULATION AND STABILIZATION FOR THE MPD-TOF DETECTOR*

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The main subject of author's research during Summer Student Program 2017 was to analyse how temperature of environment affects temperature inside the MPD-TOF. The results of research are satisfactory.

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1. Introduction

NICA (Nuclotron-based Ion Collider fAcility) is an accelerator complex designed in Dubna for the Joint Institute for Nuclear Research. The main task of that project is the examination of properties of dense baryonic matter [1]. The part of NICA complex is MPD (Multi-Purpose Detector). The MPD is designed to register particles emitted during heavy-ion collisions. Among the various components of the MPD is also the TOF (Time-Of-Flight detector) [2]. The main subject of author's research during Summer Student Program 2017 was to analyse how temperature of environment affects temperature inside the MPD-TOF.

The MPD has been designed as a 4π spectrometer able to detect electrons, photons and charged hadrons in heavy-ion collisions in the energy range of the NICA collider [3]. The detector is composed of the following subsystems [1]:

— SC Coil — SuperConductor solenoid;
— IT — Inner Detector;
— ECT — straw-tube tracker;
— TPC — Time-Projection Chamber;

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— TOF — Time-Of-Flight system;

— EMC — ElectroMagnetic Calorimeter;

— FFD — Fast Forward Detectors;

— ZD — Zero Degree Calorimeter.

2. Analysis of results

At the beginning of the work, it was necessary to create a prototypes model of MPD-TOF in the program Autodesk Inventor 2018 (Fig. 1). Aluminum was used as a material. The upper part of detector is filled with air. In the lower part, is vacuum. Four silicon elements on the acrylic plate are presented in Fig. 2. That model was also created in Autodesk Inventor 2018 program. Values of total heat generated by silicon elements were suitabled in Autodesk CFD program: 0.015 W, 0.07 W, 0.182 W, 0.195 W. Author's analysis was based on simulation of few situations, where the MPD-TOF detectors were located in different environment (the surrounding air temperature was changed).

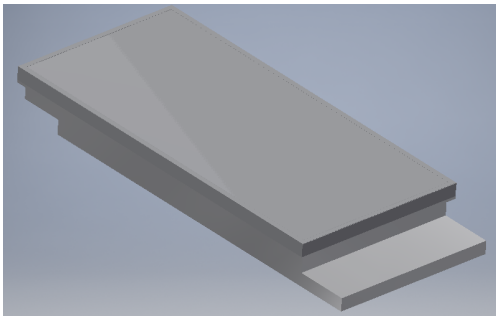

Fig. 1. MPD-TOF detector created by T.M. Lehmann in Autodesk Inventor 2018.

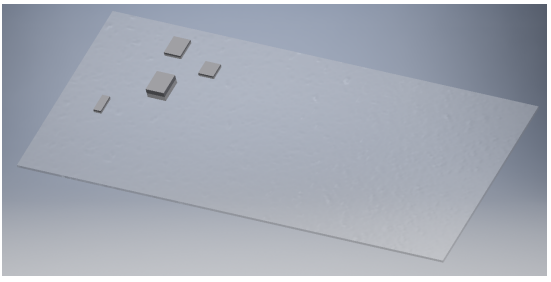

Fig. 2. Acrylic plate with silicon elements.

A picture showing how temperature changes affected the inside upper part of the MPD-TOF is attached below. Temperature in some places inside detector is much higher than 40°C. The highest temperature in Fig. 3 is almost 120°C (Picture A). It is also the highest temperature noted during simulations. In Picture B, the temperature on silicon elements is still higher than 100°C.

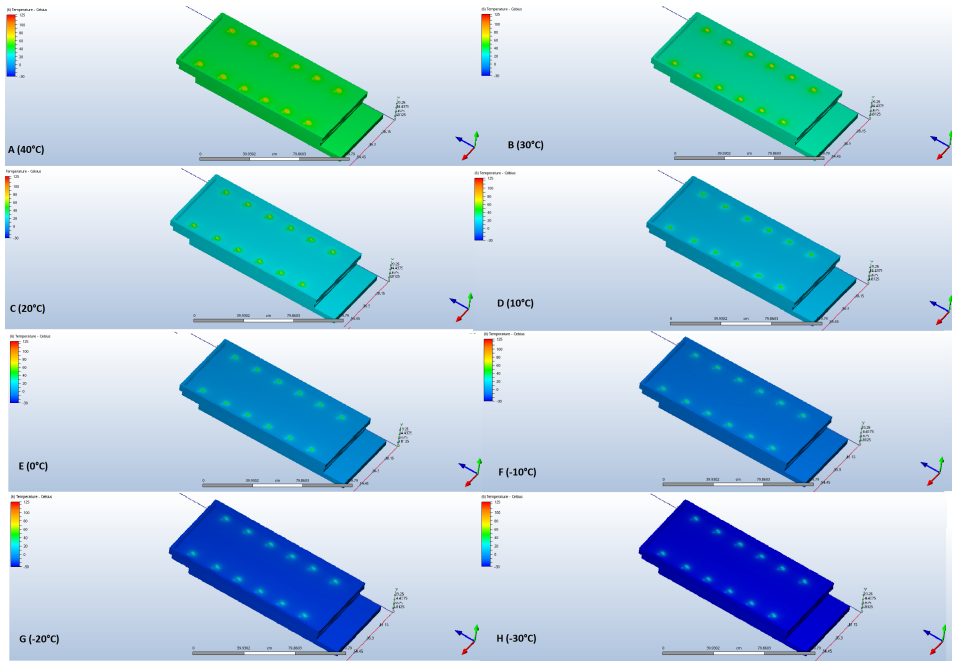

Fig. 3. The MPD-TOF detector depending on the environmental temperature. (Picture A: 40°C, Picture B: 30°C, Picture C: 20°C, Picture D: 10°C, Picture E: 0°C, Picture F: −10°C, Picture G: −20°C, Picture H: −30°C.)

If you put the detector in ambient temperature of 20°C, the temperature of silicon element will be lower than 100°C. In ambient temperature of 0°C, the temperature of the hottest elements oscillate between 40°C and 60°C. According to predictions, the temperature of heat generating elements is the lowest in the lowest ambient temperature. Under these conditions, the highest noted temperature is lower than 25°C. The temperature inside detector is expressed by equation

$$T = T_{\text{complete}} - T_{\text{environment}} \,.$$

3. Summary

The results are satisfying. The MPD-TOF detector might be a little overheated during the work in high ambient temperature (more than 30°C), because at that time, the temperature of silicon will be higher than 70°C. There will be no permanent damage, because the silicon melting temperature is 1 400°. 70°C is too much for silicon and integrated circuits may not work too efficiently. The highest temperature inside upper chamber where integrated circuits are located was not much higher than 120°C. Because of low thermal conductivity of acrylic plates, they are good separators between hot elements and the rest of detector.

REFERENCES

[1] http://nica.jinr.ru/

[2] http://mpd.jinr.ru/wp-content/uploads/2017/07/TDR_TOF_MPD_v2_20-17_07_2017.pdf

[3] K. Roslon *et al.*, *Acta Phys. Pol. B Proc. Suppl.* **9**, 299 (2016).