MPD ELECTROMAGNETIC CALORIMETER SIMULATION *

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In a frame of the NICA / MPD project, a unique cylindrical electromagnetic calorimeter (ECal) is under construction. Recently, the design of the power frame was completed. This led to significant changes of the calorimeter structure. The report gives a brief description of the new ECal geometry and the modification of simulation procedure. As part of this program, independent module options have been developed to use in the test measurements on cosmic rays and electron beams.

1. Introduction

A high priority for the Joint Institute for Nuclear Research (JINR) is a study of the nuclear matter in a hot and dense state, including quark-gluon plasma [1]. To perform this task, it was proposed a program to construct the NICA heavy-ions accelerator complex operating at high luminosity in the energy range $\sqrt{S} = 4 - 11$ GeV and modern detectors. One of such experimental setup, the Multi Purpose Detector (MPD), is optimized to investigate the states of nuclear matter, which can occur through emission of the direct photons and dileptons [2]. Therefore, the realization of this purpose is impossible without the electromagnetic calorimeter (ECal), that was included in the first phase of the MPD assembly. Taking into account various factors such as high energy and time resolution, small Moliere radius, capability to operate in the magnetic field and low price allowed to select a shashlik-type calorimeter [3]. The calorimeter cell (tower) of that type has a sampling structure consisting of active medium (scintillator) and absorber

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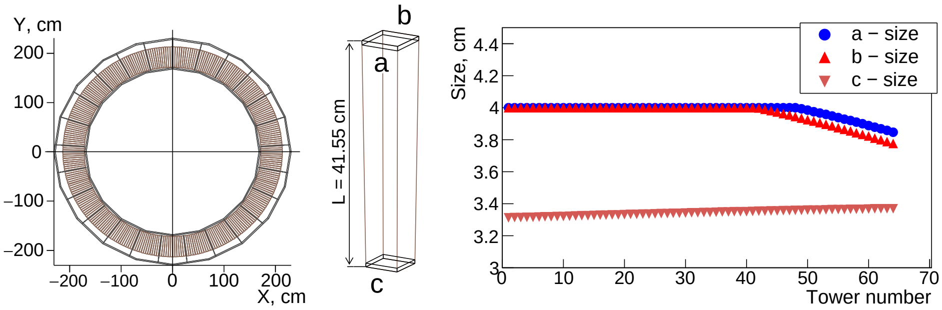

Fig. 1. Front view of the ECal and one calorimeter tower (left). Tower spatial sizes a, b, and c for different towers (right).

(lead). All towers form a barrel structure having a high segmentation as well as a projective geometry, which contains all calorimeter towers oriented to the NICA collider beams crossing area. The significant modifications of the MPD power supporting frame proposed in the JINR design department led to important changes in the ECal structure and tower parameters. This paper describes the latest alterations in the geometry and resulting changes of physical parameters obtained from the MC simulation.

2. New ECal design

According to the new design concept, the power supporting frame is a barrel structure with inner radius equal to 168 cm (Fig. 1, left). Inner radial wall of the power frame has a width of 2.5 cm. 25 bulkheads of 1-cm thick provide high strength of the frame, which will be produced from lightweight carbon-fiber compound. 50 baskets will be placed inside power frame. Baskets are required to accommodate the calorimeter modules and corresponding electronics. Each basket contains 48 modules; 8 modules of different shapes are arranged in a row along Z-axis, 6 of the same shape - in XY plane. The total weight of the basket is about 1.2 tons. Each module consists from 16 towers fixed by the special glue. The entire ECal has 38400 towers. Generally, each tower consists from 210 layers forming from 1.5-mm-thick scintillator plate and 0.3-mm-thick lead plate coated with reflective paint. Total length of tower is 41.55 cm, or about 11 radiation length. The shapes of the towers are approximately truncated pyramids with base of $4{\times}4$ cm^2, more accurately described by a set of trapezoids. Two milling angles equal to 0.9^0 along Z-axis and to 1.2^0 in XY-plane define 64 types of the tower shapes, which can be described by three spatial sizes a, b, c

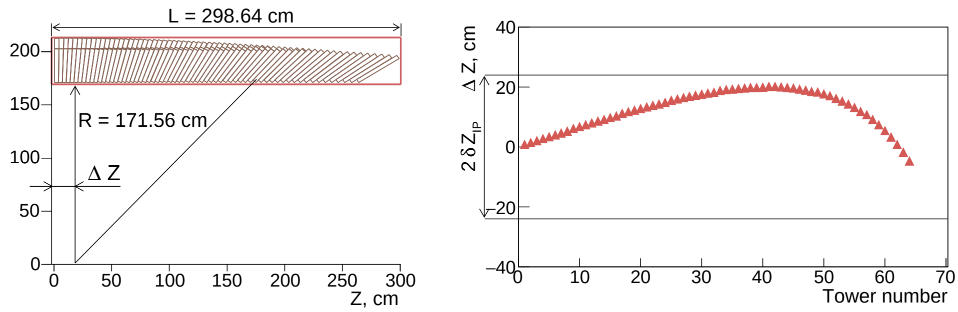

Fig. 2. Tower location in the Z-plane (left) and dependence of the parameter ΔZ vs tower number.

(Fig. 1, left). The behavior of these parameters as a function of the tower number is shown in 1 (right). The towers are arranged to look at the beam intersection point determining so-called projective geometry [4]. The location of the towers in the Z-plane is presented in 2 (left), where parameter ΔZ defines the tower offset relative to the zero point. It's expected that the Gaussian smearing (δZ_{IP}) of the NICA collider interaction point is 24 cm, so the fluctuation of ΔZ around zero does not exceed δZ_{IP} (2, right).

3. Calorimeter simulation with a simple clustering algorithm

The total ECal geometry is stored in ROOT file emc_v3.root, where v3 is the current version number. In order to find the energy deposition in tower, it's necessary to sum all GEANT4 points in the active volume (scintillator). The his coordinates are defined as the center of tower, which special location can be defined by two numbers: the number N_ϕ in ϕ-angle (from 0 to 299) and the number N_Z along Z-axis (from 0 to 127) [5]. The cluster algorithm is based on the merging neighboring hits inside the grid $N_\phi \times N_Z$ starting from the central hit with maximal energy deposition. The cluster energy is defined as a sum of hit energies, while the coordinate is calculated by energy weighting sum of the coordinates of hit centers. The energy threshold of each hit was equal to 5 MeV. The following analysis of the ECal physical parameters was based on this cluster algorithm. The implementation of the various walls and edges as part of power frame leads to an enlargement of the reconstructed spectra and tails in the low energy region [5, 6]. Fig. 3 (left) is shown the energy of cluster from γ's as a function of θ-angle. Photons are well reconstructed in the θ-angle region from 35^0 to 145^0. The effective mass of two γ's reconstructed from π^0 decays at p = 200 MeV/c is shown in 3 (right). This distribution is given for two calculations. In the first case, the simulation was performed for full MPD geometry including the different detectors (TOF and TDC) and the power frame (PF); in the other case only calorimeter modules were taking into account. A significant distortion of the effective mass distribution by shape is seen; an essential tail at low energy range is clearly manifested in the first case.

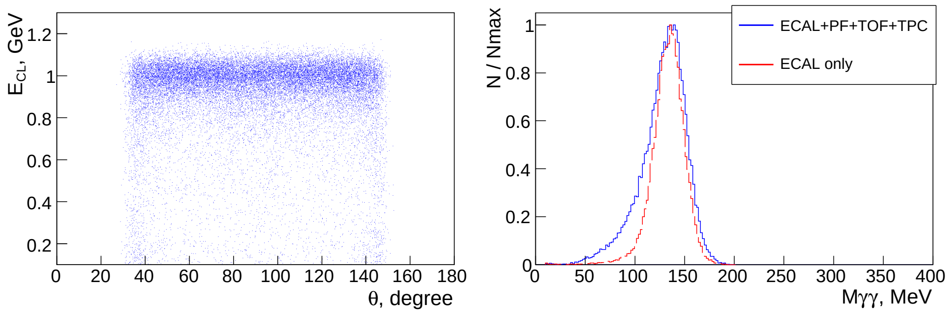

Fig. 3. Cluster energy produced by single photon vs θ-angle at Eγ = 1 GeV (left). Reconstructed $\gamma\gamma$ effective mass from π^0 decays at p = 200 MeV/c (right).

4. Conclusion

A new geometry program of the MPD electromagnetic calorimeter has been created and stored in the ROOT-file to be used in the MpdRoot software. It includes special supporting structures, calorimetric modules and a new description of the minimal calorimeter cell - tower. Corresponding physical distributions simulated for photons of the different energies have been shown. This work was supported by RFBR grants No. 18-02-40054 and No. 18-02-40079.

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